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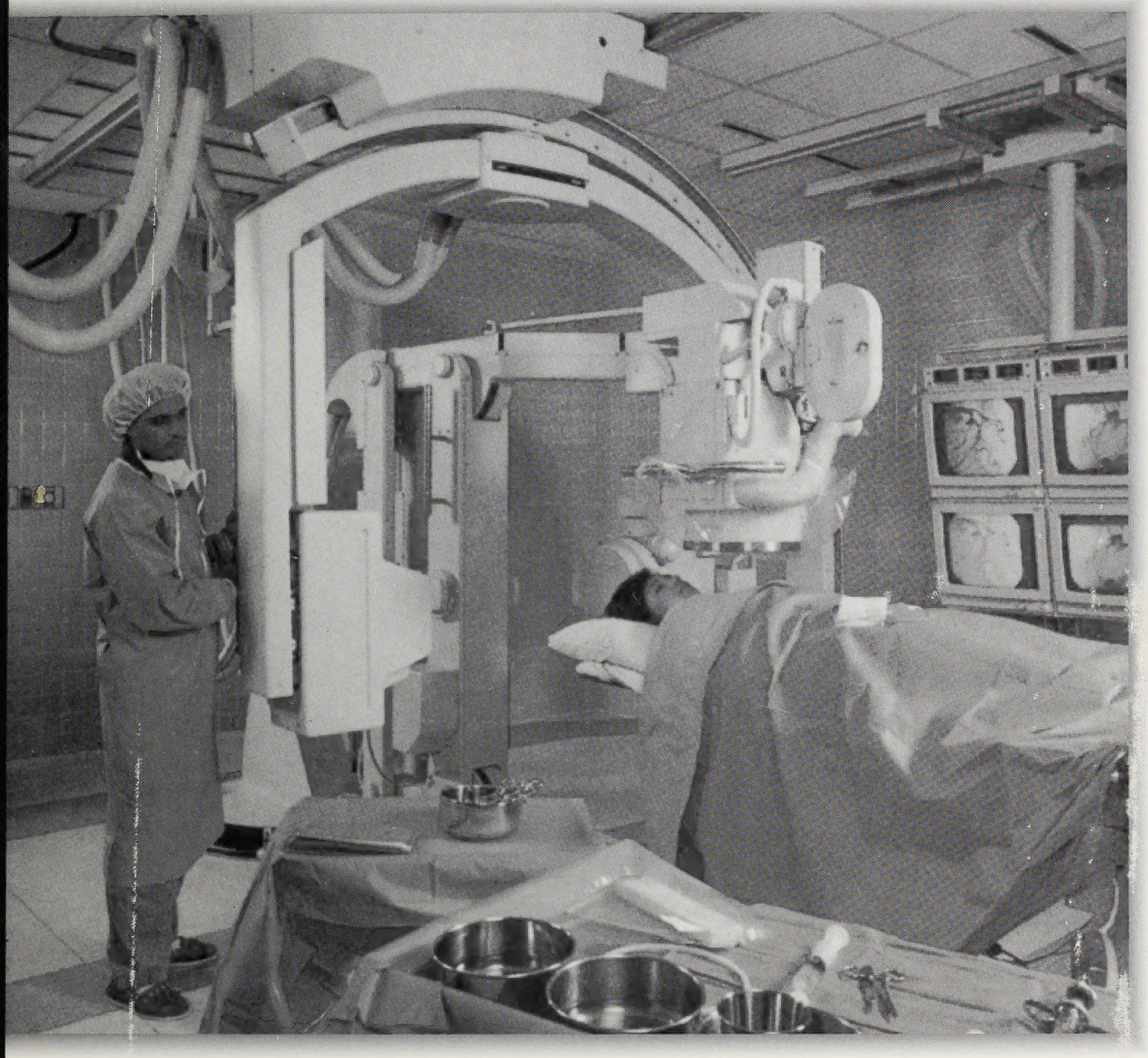
# Science 30

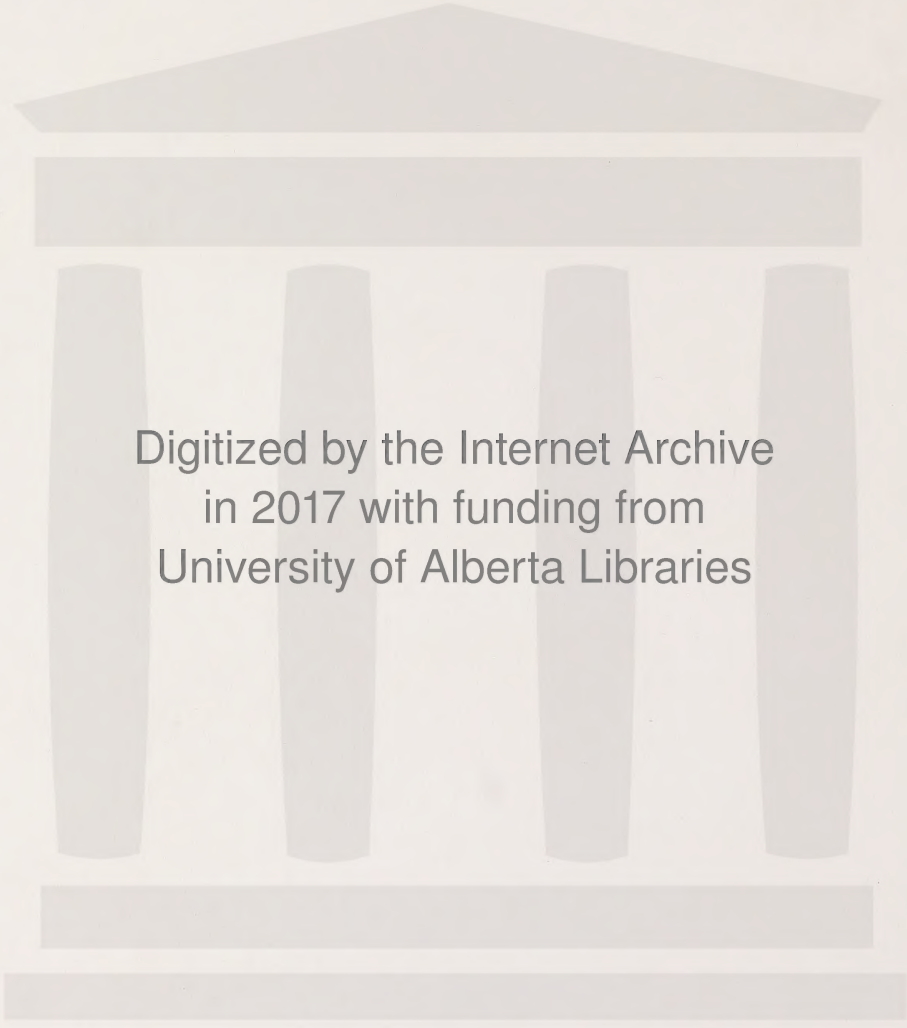


## MODULE 1

## Body Systems in Balance

Distance Learning

Alberta EDUCATION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SEP 14

Science 30

# Module 1

# Body Systems in Balance

Alberta
EDUCATION

| This document is intended for | |
|---|---|
| Students | ✓ |
| Teachers (Science 30) | ✓ |
| Administrators | |
| Parents | |
| General Public | |
| Other | |

Science 30
Student Module
Module 1
Body Systems in Balance
Alberta Distance Learning Centre
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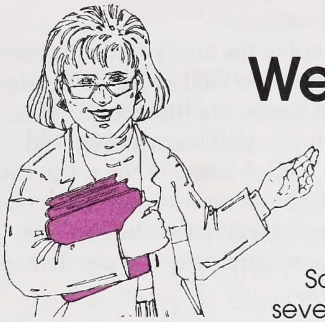


# Welcome to Science 30!

The document you are presently reading is called a student module booklet. It will take you through the course and show you, step by step, what to do and how to do it.

Science 30 has eight modules. Each module comprises several sections. Within each section, your work is grouped into activities. Within the activities, there are readings, explanations, and questions for you to work through. You will correct these activities yourself using the Appendix at the end of each module. This will provide you with immediate feedback on your progress.

Your grading in the course is based upon the assignments that you submit for evaluation and upon the final test.

We hope you'll enjoy your study of Body Systems in Balance in this module.

To make your learning a bit easier, watch the referenced videocassettes whenever you see this icon.

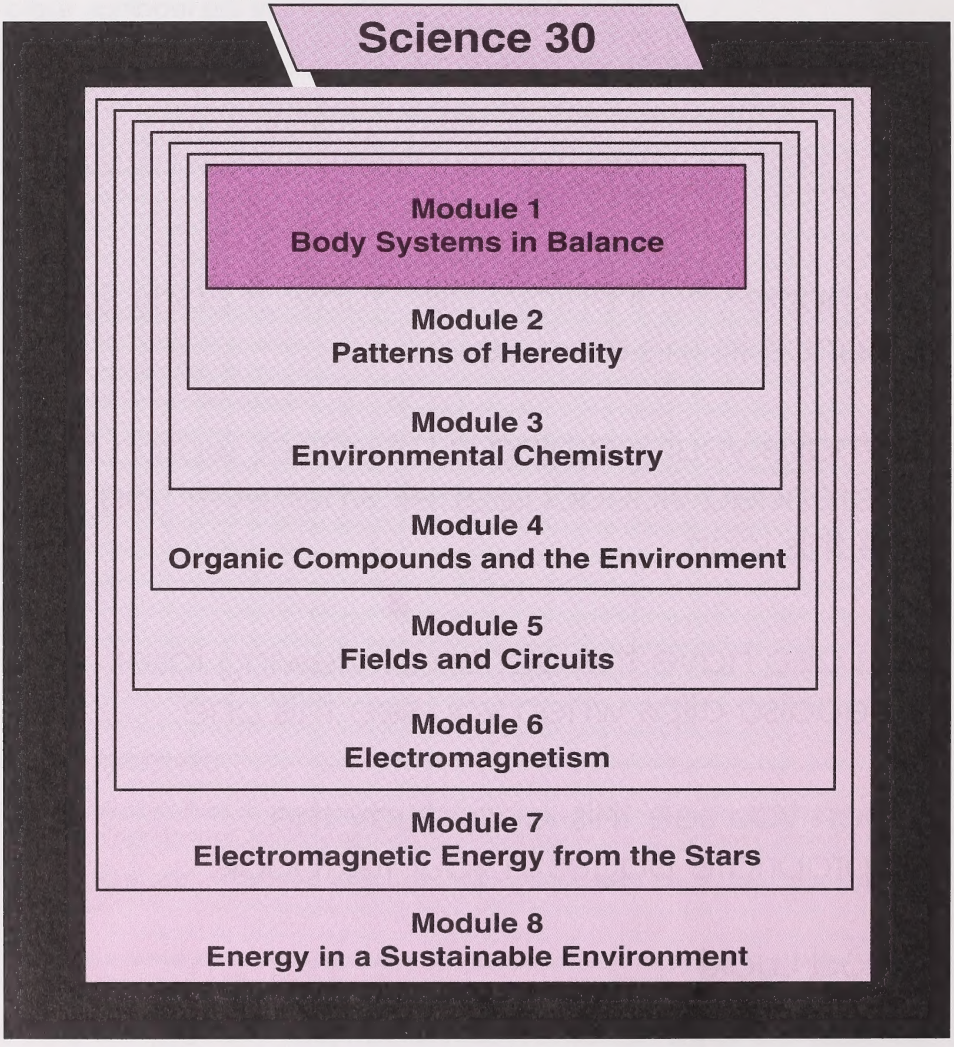
You also have the option of viewing laser videodisc clips when you see this one.

When you see this icon, study the appropriate pages in your textbook.

Good Luck!

# Course Overview

This course contains eight modules. Modules 1 and 2 involve the study of the human circulatory system, defence mechanisms, the nervous system, as well as the principles of genetics. Modules 3 and 4 involve the study of acids and bases, organic compounds, and their effects on the environment. In Modules 5 and 6 you will learn about field theory and the operation of various electrical devices, as well as some of the properties of electromagnetic waves. In Module 7 you focus on the electromagnetic spectrum and its relation to the study of the Universe. Module 8 will involve the study of the various sources of energy and how a balance must be maintained between the demand for energy and the need to maintain a viable environment.



# Table of Contents


**Module Overview** ..... 1
- Evaluation ..... 2
- Science Skills ..... 2

**Section 1: The Human Transport System** ..... 6
- Activity 1: Science Skills ..... 7
- Activity 2: The Pumping Heart ..... 11
- Activity 3: Blood Vessels ..... 14
- Activity 4: A Bloody Affair ..... 21
- Activity 5: Control Mechanisms ..... 30
- Follow-up Activities ..... 37
  - Extra Help ..... 37
  - Enrichment ..... 40
- Conclusion ..... 41
- Assignment ..... 41

**Section 2: Defence! Defence!** ..... 42
- Activity 1: Nonspecific Defence Mechanisms ..... 43
- Activity 2: Specific Defence Mechanisms ..... 46
- Follow-up Activities ..... 52
  - Extra Help ..... 53
  - Enrichment ..... 54
- Conclusion ..... 55
- Assignment ..... 55

**Section 3: How Are Your Nerves?** ..... 56
- Activity 1: The Neuron and the Nerve Impulse ..... 57
- Activity 2: Sight, Balance, and Touch ..... 62
- Activity 3: The Organization of the Nervous System ..... 68
- Activity 4: Putting It All Together ..... 73
- Follow-up Activities ..... 78
  - Extra Help ..... 78
  - Enrichment ..... 81
- Conclusion ..... 82
- Assignment ..... 83

**Module Summary** ..... 83

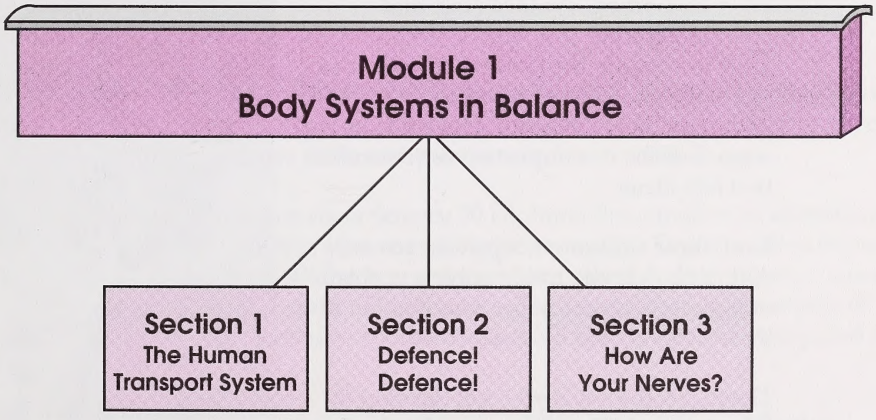
**Appendix** ..... 84
- Glossary ..... 85
- Science Skills ..... 85
- Suggested Answers ..... 93
- Science Data Booklet ..... 125

# MODULE OVERVIEW

Have you ever tried walking on something where you had to keep your balance to keep from falling over? Do some personal experiences come to mind? Some examples may include walking on small rocks to get across a stream, walking along the top of a fence, exercising on a balance beam, or running along a log in the water.

Similar to you having to maintain your balance in various instances, your internal body must also maintain a state of balance or equilibrium with its environment. This module focuses on the mechanisms living organisms use to maintain a state of constancy or of keeping body processes balanced within a changing external environment using the human organism as a model. The state of balance the body tries to maintain in its development is known as homeostasis. The systems to be discussed will include the circulatory system, the immune system, and the nervous system.

In Science 10 you learned about the processes of diffusion, active transport, and osmosis. In Science 20 you studied changes in living systems which have allowed organisms to adapt to their environments. This module will build on these previous concepts you have studied by examining the human circulatory system and how it interacts with its environment. It will explore human defence mechanisms and how they can provide protection against disease and adverse environments. Finally, the module will study the nervous system and how it mediates the interaction of humans with their environment.



# Evaluation

Your mark in this module will be determined by how well you complete the assignments at the end of each section. You must complete all assignments. In this module you are expected to complete three section assignments. The mark distribution is as follows:

| | |
|---|---|
| **Section 1 Assignment** | **35 marks** |
| **Section 2 Assignment** | **30 marks** |
| **Section 3 Assignment** | **35 marks** |
| **TOTAL** | **100 marks** |

When doing your assignments, work slowly and carefully. If you are having difficulties, go back and review the appropriate section.

# Science Skills

One of the exciting features of this course is that you will develop and improve your ability in the area of science skills. These skills include

- initiating and planning
- collecting and recording
- organizing and communicating
- analysing
- connecting, synthesizing, and integrating
- evaluating the process or outcomes

Although these skills are referred to as science skills, it is important to remember two key ideas.

First, these skills are not just for science. Any time that you might solve a problem or make a decision, some combination of these skills would be used.

Therefore, the skills you will develop in this course will be very useful for life-long learning. Nearly every activity of your life will require you to solve a problem or make a decision. Some people would even argue that, in the long run, the skills are more important than the particular topics that you study.

NASA

Secondly, you will be free to use these skills in a variety of ways. It would be wrong to assume that every scientist uses these skills in the same way to solve every problem. Science is very much a human activity, which means individuality and creativity play a large role.

The society that the person lives in, the technology that is available, and the very personality of the scientist will determine which skills are combined to create a solution to a problem.

It follows from this idea that the science that you do and the science skills that you prefer to use will be unique to you, and that's OK. It also follows that you likely will not be performing at the same level for all skills, which is a natural thing. In this course you will continually practise all of these skills and you will have an opportunity to assess your level of performance in each skill.

These science skills will be developed further in Activity 1 and explained in detail in the Appendix for this module.

NASA

## Important Notes

- If you completed Science 20 through distance learning, Activity 1 of this module will be familiar to you. You may choose to review the activity briefly to refresh your memory on science skills and then proceed to Activity 2.

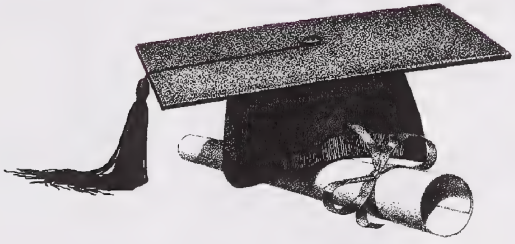
- You will be required to write a Science 30 Diploma Examination in addition to a distance learning final test after completing this course. Therefore, it is important for you to be familiar with the types of questions asked and the types of answers expected on a diploma exam. This course will give you various examples of diploma exam-type questions and instructions to enable you to be prepared fully for the final exam.

- You will be doing several investigations involving acids, bases, and other chemicals that could cause damage to a table surface. It is recommended that you perform your investigations on a plastic tablecloth or on some resistant surface. Also, make sure that you check the materials required for each investigation to see what substances or equipment must be supplied by you.

- There are no response lines included with the activity questions asked in the student module booklets of this course. This means that you will need to have paper on which to answer the questions handy at all times. It's probably a good idea if you keep your answer pages in a binder or folder. You will also require your *Visions 3* textbook, graph paper, and a calculator. Read all the questions carefully and answer them as completely as possible. Then check your answers in the Appendix. This will allow you to assess your growing abilities in this course.

- It is also important that you work through the section activities thoroughly before attempting the assignment questions. This will help you to achieve a greater degree of success in your studies.

## Diploma Exam Preparation



Since you will be writing a Science 30 Diploma Examination when you have finished this course, it's important that you are familiar with the types of questions that will be asked and the format in which they will be presented. From time to time, throughout the modules in this course, you may be given several activity questions and assignment questions of diploma exam format so that you can become familiar with these types of questions. For more detailed information on preparing for diploma exams, consult Activity 4 in Module 8.

There are three basic types of questions you will encounter on a Science 30 Diploma Examination:

- **Multiple Choice:** With each question you are given several (usually four) alternative answers, listed by A., B., C., and D. from which you choose the single **best** possible answer. Each multiple choice question is worth one mark. You record your choice for each question by letter on a separate answer sheet provided.

- **Written Response:** Written response questions are multiple-mark questions in which you are expected to show all your work and organize and present your answer in a clear and precise manner. Marks may be given for clarity in the communication of your answer as well as the shown calculation work. You will be given several activity and assignment questions of this question style.

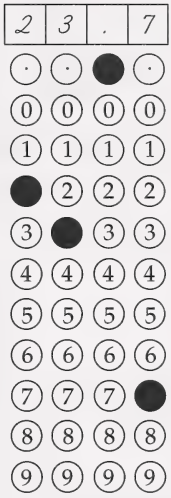
- **Numerical Response:** A numerical response question is designed so that you must record your answer, but you do not show your work. There are two basic types of numerical response questions: calculation questions and correct-order questions. Whichever type, you will be expected to record your answer on the same type of machine-scored answer sheet. Two samples are as follows:

***Sample Calculation Question and Solution***

The mass in grams of silver produced when 0.220 mol of silver nitrate reacts with excess copper is _____ g. (Record your answer to three digits.)

$$\text{mass}_{Ag} = 0.220 \text{ mol} \times 107.87 \text{ g/mol}$$
$$= 23.7314 \text{ g}$$
$$= 23.7 \text{ g (rounded to three digits)}$$

Record 23.7 on the answer sheet. →




Notice that the decimal in the calculated value uses one of the four spaces in the answer box.

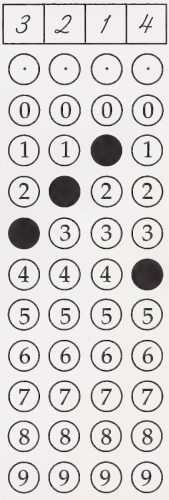
***Sample Correct-order Question and Solution***

When the following subjects are arranged in alphabetical order, the order is _____. (Record all four digits.)

1. mathematics
2. chemistry
3. biology
4. physics

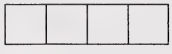
Answer 3, 2, 1, 4.

Record 3214 on the answer sheet. →




This is the way you would "bubble" in your answer on a diploma exam. →

For practising this type of question, you may be asked in an assignment question, for example, to place your response in a four-place box similar to the following:



This is just to get you used to answering these questions in the correct way. Notice that this is the same box used on the top of the sample answer sheets shown previously. Each numerical response question is worth one mark.

Section

# 1 The Human Transport System

NASA

What is the function of your heart? Why is this function important? What material flows through your heart? Do you know the purpose of this material?

The introduction of laser angioplasty shown in the photograph has reduced the need for major open-heart surgery. Anyone who has had heart surgery or heart problems knows the vital importance of this organ and the entire circulatory system.

The heart and blood represent major components of the circulatory system. In this section you will learn the importance of this system in keeping your body in equilibrium. You will explore the structure of the circulatory system; then you will investigate the components of blood and its significance. The last activity of the section will examine the regulation of the circulatory system.

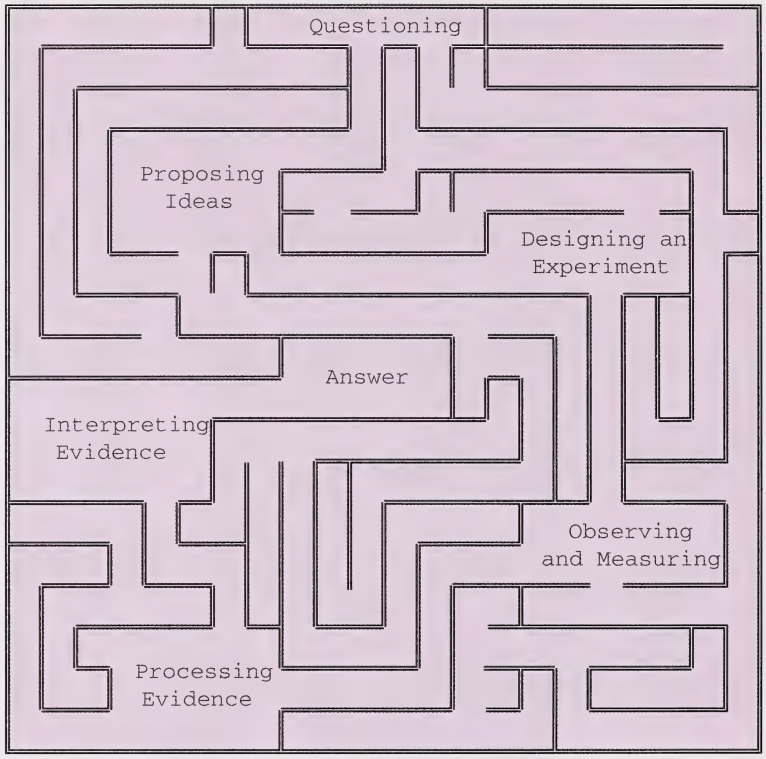
# Activity 1: Science Skills

Science is not concerned only with the accumulation of knowledge. It is also concerned with carrying out scientific investigations that solve problems and answer questions. This is called research. The activities used while doing research or solving problems are commonly referred to as science skills. These are fundamental to the methodology of science. Scientists and science students use their science skills to help them find reliable answers to the questions about the world around them.

COURTESY OF TERRY SLIWKANICH

Science skills can be organized in a logical sequence that leads from a problem or question through investigations to solutions or answers. The steps are very useful.

1. Carefully follow the maze to find the sequence of science skills. Start with Questioning and work your way in to the Answer.




2. Make a list of the science skills so you can clearly see the correct sequence.

Check your answers by turning to the Appendix, Section 1: Activity 1.

You'll learn and practise science skills throughout Science 30. Science skills may also be a part of your section assignments and final examinations. Hopefully they will become a part of the way you do science.

## Science Skills for Science 30

Following is a list of general science skills developed in this course. A more detailed explanation of each skill is given in the Appendix of this module. Read the defining statements for each of the following science skills carefully. You should recall working with these skills in Science 20 or other previous science courses you may have taken.

A. Initiating and planning
B. Collecting and recording
C. Organizing and communicating
D. Analysing
E. Connecting, synthesizing, integrating
F. Evaluating progress or outcome

As a student in science you may use certain skills only at certain times. You are not expected to be an expert in the very beginning. Good skills take time to develop and they improve with practice and experience. To help you keep track of your growth in science skills, take a look at the skill levels in the Appendix. Compare Level 1 to Level 4 under *A. Initiating and Planning*. Notice how the skill level changes. Level 5 may be expected of students in college or university. As a senior high school student you may already have some skills at Level 3 or 4. Can you draw a graph correctly? Check Level 3 in *C. Organizing and Communicating* in the Appendix. Science skills are developed in Science 30 in a user-friendly way. Throughout the modules, skill icons will tell you when particular skills are applied. Notice the skill icon beside question 4 in Section 1, Activity 2.

Now turn to question 8 in the assignment for Section 1. Do not try to answer the question at this time, but look at the skill icon. In this question you will practise analysing and synthesizing information. Also notice the self-assessment instructions after the questions. The self-assessment of your science skills is an opportunity for you to communicate your level of skill development to your teacher marker.

Assume that after answering question 8 you felt your skills were quite good so you filled in the skill assessment box like the one that follows.

| | A. | B. | C. | D. | E. | F. |
|---|---|---|---|---|---|---|
| Self: | | | | 4 | 3 | |
| Teacher: | | | | | | |

And when the teacher assessed your science skills they indicated this:

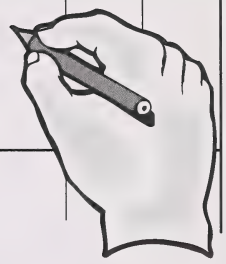
| | A. | B. | C. | D. | E. | F. |
|---|---|---|---|---|---|---|
| Self: | | | | 4 | 3 | |
| Teacher: | | | | 3 | 4 | |

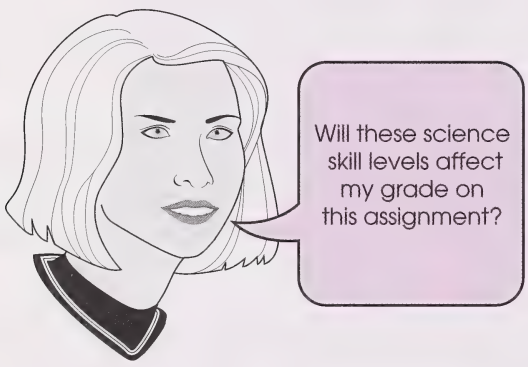
By comparing your assessment to the teacher assessment you can see they are very close. A little improvement could be made in Skill D, but in Skill E you are at Level 4 already. A good start! The teacher marker may write you a short note explaining any differences.

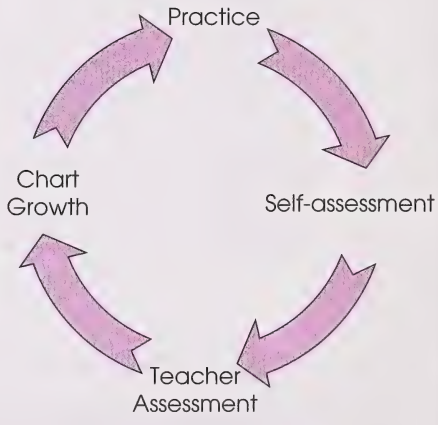
Now you would record both your assessment and the teacher assessment on the data sheet at the back of Module 1.

**SKILL ASSESSMENT RECORD**

| Feedback from Assignments | | | Initiating and Planning | | Collecting and Recording | | Organizing and Communicating | | Analysing | | Synthesizing and Integrating | | Evaluating | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Module | Section | Question | Self | Teacher | Self | Teacher | Self | Teacher | Self | Teacher | Self | Teacher | Self | Teacher |
| 1 | 1 | 8 | | | | | | | 4 | 3 | 3 | 4 | | |
| | | | | | | | | | | | | | | |






It is important for you to realize that the teacher skill-level assessment should **not** be interpreted as part of your grade. Rather, it is valuable feedback to help you to know the areas where you need to improve. Everyone can improve science skills.

In Science 30 you will use science skills in a variety of ways such as making charts, drawing diagrams, writing research papers, as well as doing lab investigations. To learn more about using science skills, return to question 4 in Activity 2. Beside this question you see the science skills box. This science skill box applies to question 4 to 10 which deal with blood flow and the structure of the heart. The science skills of collecting, analysing, and synthesizing are checked in the box. Carefully read this section keeping these skills in mind. Answer the questions which follow.

3. In what parts of this exercise do you find the science skill of collecting?

4. In what parts of this exercise do you find the science skill of analysing?

5. In what parts of this exercise do you find the science skill of synthesizing?

6. In what part of this exercise do you find the science skill of initiating?

If you are having difficulty answering these questions, you may wish to return to this part after you have done this section in Activity 2.

7. What level are you working at in each of the science skills? (This question is best left until you have done the exercise in Activity 2.)

Check your answers by turning to the Appendix, Section 1: Activity 1.

Although you do not have to rate your skill level when doing the exercises in the student module, you will have to rate your skill level for some questions in the assignment booklet. You may wish to practise rating your science skills as you do the exercises and investigations in the student module book. Refer to the Criteria for Assessing Scientific Problem-Solving Skills at the beginning of the Appendix in Module 1.

The skills you develop and improve upon now will not only benefit you in your further science studies, but may help you tackle any general problems in life.

## Activity 2: The Pumping Heart

Visions

A system can be thought of as any collection of linked objects, cells, or processes. A human system is made up of one or more organs. The major organ in the circulatory system is the heart. This incredible machine beats at least 100 000 times a day and about three billion times in a lifetime. Because of its extraordinary workload, it is composed of its own type of muscle. To introduce you to this amazing structure, read pages 3 and 4 of your text and answer the following questions.

1. Why is a circulatory system required in multicellular organisms but not in unicellular organisms?

2. How long does it take for an oxygen molecule to diffuse across a cell? How long would it take for an oxygen molecule to diffuse from your lungs to your calf muscle? What does this data illustrate?

3. How many pumps does your heart function as? Describe what each of the pumps does.

Check your answers by turning to the Appendix, Section 1: Activity 2.

The human heart is composed of four chambers. The top two chambers are know as atria (singular—atrium) and the bottom two chambers are ventricles. There are a number of blood vessels that protrude from the heart. To learn more about the structure of the heart, use the Precise Photographic Guide of the Pig Heart found in your loan kit and follow the steps indicated on pages 5 and 6 of *Visions* 3. Use this information to complete questions 4 to 10 in this section. If you have access to a preserved dissected heart, model, or computer simulation, you may use any of these to complete this section of Module 1.

4. Do Textbook step 1 of the Procedure on page 5 of your text. Note: Your drawing should be done on a piece of $8\frac{1}{2}'' \times 11''$ sheet of paper and presented as a ventral view. That means that you should draw it as if you were looking down at someone's chest to do the drawing. Therefore, the right side of the heart will be on the left side of your page and vice versa.

For questions 5 to 9, you are provided with checklists. As you label the particular structures in your drawing, check off the appropriate boxes. Carefully study the photograph in the Precise Photographic Guide of the Pig Heart as well, but do not mark or write on the photograph. The number of the particular parts from the Precise Photographic Guide of the Pig Heart are given in brackets after the appropriate name.

5. Do Textbook step 2 of the Procedure on page 5 of your text.

Checklist: [ ] inferior vena cava (not shown)

[ ] superior vena cava (20)

[ ] right atrium (13)

6. Do Textbook step 3 of the Procedure on page 5 of your text.

   Checklist: [ ] right ventricle (15)

7. Do Textbook step 4 of the Procedure on page 5 of your text.

   Checklist: [ ] tricuspid valve (24)

8. Do Textbook step 5 of the Procedure on page 5 of your text.

   Checklist: [ ] pulmonary artery (19)

   [ ] pulmonary semilunar valve (22)

9. Do Textbook step 6 of the Procedure on page 5 of your text.

   Checklist: [ ] pulmonary veins (not shown)

   [ ] left atrium (14)

   [ ] left ventricle (16)

   [ ] bicuspid (mitral) valve (23)

   [ ] aorta (17)

   [ ] aortic semilunar valve (21)

10. Do Textbook questions 1 to 8 in Analysis and Interpretation on page 6 of your text.

Check your answers by turning to the Appendix, Section 1: Activity 2.

**DID YOU KNOW?**

Athletes in excellent physical condition have much slower heart rates because they have greater stroke volumes (volume of blood pumped/heartbeat). In comparison to the normal 72 beats/min, resting heart rates of 35 beats/min have been recorded in athletes.

In this activity you have been given the opportunity to explore the structure and function of the heart. You should also be familiar with the major blood vessels going into and out of the heart. In the next activity you will gain an understanding of the structure and function of the blood vessels.

# Activity 3: Blood Vessels

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What types of food do you enjoy every day? Do you know whether or not the foods you eat contain cholesterol? Cholesterol is a major topic of discussion among people young and old.

Cholesterol testing has become a routine part of a medical examination. There is a definite link between cholesterol and your blood vessels. In this activity you will learn about the structure of the various types of blood vessels and their functions. You will research problems that can occur with the blood vessels, namely cholesterol buildup in the arteries.

To learn about the structure and function of the blood vessels in the circulatory system, read pages 7 to 11 of *Visions 3* and answer the following questions.

1. Make and complete a table like the following to distinguish between arteries, capillaries, and veins. With respect to structure, try to explain reasoning for the thickness found in each vessel type. You will have to allow for the appropriate amount of space in each row.

| Blood Vessel Type | Structure with regards to the thickness of the walls | Function |
|---|---|---|
| Arteries | | |
| Capillaries | | |
| Veins | | |

2. Now, think back to the anatomy of the heart and its blood vessels. Do all arteries carry oxygenated blood? Explain your answer. Do all veins carry deoxygenated blood? Explain your answer.

3. Small arteries are known as _____, while small veins are known as _____.

4. Compare the elasticity, found in the walls, between arteries and veins. Explain the reasoning for the elasticity found in arteries.

**TO HELP YOU REMEMBER**

When you cut a vein, which is usually near the skin surface, the blood flows out continuously. However, when you cut an artery, which is deeper in the body, blood spurts out because of the greater pressure and the pulsing action.

5. Do Textbook question 4 under Checkpoint on page 11 of your text.

6. List three reasons why capillaries are excellent areas for exchange.

Check your answers by turning to the Appendix, Section 1: Activity 3.

**TO HELP YOU REMEMBER**

Arteries and veins can be thought of as the major freeways in a road system because the blood is flowing very fast. Capillaries, on the other hand, can be thought of as the roads found downtown in a large city during rush hour where traffic flow is slow.

## Investigation: The Nature of Blood Flow in Capillaries and Veins

### Purpose

Observe the nature of blood flow in capillaries and veins.

## Part A: Observing Capillaries

**PATHWAYS**

If you have access to a live goldfish or guppy, do Pathway A. If you do not have access to this, do Pathway B.

## Pathway A

### Materials

- live goldfish or guppy
- petri dish
- cloth or paper towels
- medicine dropper
- glass of water
- magnifying glass or microscope (if available)

### Procedure

**Step 1:** Obtain a live goldfish or guppy and wrap its body, except for the tail, in a wet cloth or paper towel.

**Step 2:** Place the wrapped fish in a petri dish with a layer of water in it.

**Step 3:** Observe the blood vessels in the tail using a magnifying glass or microscope.

**Step 4:** Every few minutes add drops of water to the tail to keep it moist.

**Step 5:** Once you have completed the observations, return the fish to its tank or jar.

### Observations

7. Design a table to record observations on capillaries with respect to the relative wall thickness, diameter, and velocity of blood flow.

### Analysis and Interpretation

8. Based on your observations, explain the functional significance of the structural characteristics.

Check your answers by turning to the Appendix, Section 1: Activity 3.

## Pathway B

### Materials

- Diagram and information given in the Observations section of this pathway

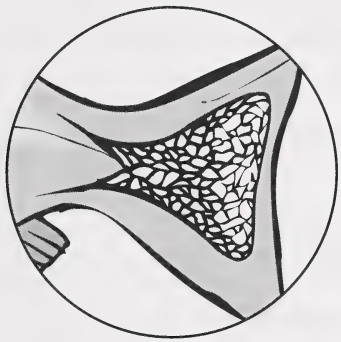
### Procedure

**Step 1:** Study the diagram of a fish tail observed under a microscope.

**Step 2:** Note the different sizes of the blood vessels in the tail.

### Observations

Diagram of fish tail under a microscope



In addition to the different sizes of blood vessels, it was also observed that the blood was not moving very quickly through the capillaries.

### Analysis and Interpretation

Return to Part A and answer questions 7 and 8.

Check your answers by turning to the Appendix, Section 1: Activity 3.

Science Skills
- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

## Part B: Observing Veins

### Purpose

Observe how blood flows in the veins in a human forearm.

### Materials

- your forearm or a friend's forearm
- pencil and paper

### Procedure

**Step 1:** For the best results, work with a partner. Have the partner leave his or her right arm hanging by his or her side for two minutes to let the veins fill with blood.

**Step 2:** Have your partner place his or her arm on a table and note the large blue veins on the inner forearm.

**Step 3:** Using your index finger, apply pressure to a vein close to the elbow and maintain this pressure while sliding your finger down the path of the vein towards your partner's hand.

**Step 4:** Record your observations.

**Step 5:** Now reapply the pressure to a vein near the wrist and maintain this pressure while sliding your finger up the path of the vein towards the elbow.

**Step 6:** Record your observations.

### Observations

9. Design a table and record your observations.

### Analysis and Interpretation

10. Explain the difference in the results obtained.

Check your answers by turning to the Appendix, Section 1: Activity 3.

**DID YOU KNOW?**

Varicose veins are due to defective or damaged valves. This results in the pooling of blood in one place. Varicose veins usually appear in the legs. People most vulnerable to varicose veins are those who have inherited weak valves, those who have jobs which require long hours of standing, or pregnant women.

Visions

Review pages 7 to 11 of your textbook and answer the following questions.

11. Define the process of diffusion.

12. Design a simple flow chart illustrating the diffusion of carbon dioxide and oxygen in the circulatory system. (Use arrows to show the direction of gas flow between the blood and the cells.)

13. Discuss the process of bulk flow.

14. What role does the lymphatic system play with respect to the circulatory system?

15. What is the function of the valves found in the larger vessels of the lymphatic system?

16. Create a flow chart illustrating the flow of blood through the body using the following terms: *arteries*, *veins*, *capillaries*, *arterioles*, *venules*, and *heart*.

Check your answers by turning to the Appendix, Section 1: Activity 3.

Visions

Now that you have a good understanding of the blood vessels in the circulatory system, examine some problems found in the circulatory system. Read page 12 of your text and answer the following questions.

17. What is the best defence against circulatory system problems?

18. Describe the function of the coronary arteries.

19. Define the term *atherosclerosis*.

20. If atherosclerosis is not treated, what are some possible consequences?

21. Identify and describe two treatments for atherosclerosis.

Check your answers by turning to the Appendix, Section 1: Activity 3.

## The Cholesterol Story

One of the key contributors to atherosclerosis is cholesterol. Cholesterol is a fat-like substance which is acquired by diet, especially in red meat, egg yolk, and whole milk products. It is a substance that is required by the body and is produced in the liver. Cholesterol serves a number of important functions in the body. It is a component of cell membranes and is used to produce bile salts (digestive function), vitamin D (aids in the absorption of calcium), and the sex hormones.

Problems occur when cholesterol reaches high concentrations in the body and precipitates out into the blood stream. This may begin in the teenage years or earlier. A higher concentration results in a buildup of plaque in various arteries which results in the reduction in diameter of the vessel. Consequently, an increase in blood pressure occurs.

**TO HELP YOU REMEMBER**

What do you do when you want the water in a garden hose to spray a further distance? By placing your thumb over the garden hose to increase the distance of the spray, what have you done? In essence, you have reduced the diameter of the hose causing an increase in pressure. This is very similar to what happens in your arteries when there is a cholesterol buildup.

There are two types of cholesterol in your body—"bad" cholesterol and "good" cholesterol. The "bad" is low-density lipoprotein (LDL) cholesterol which may accumulate in large amounts in the blood. The "good" is high-density lipoprotein (HDL) cholesterol which functions to decrease the cholesterol in the blood. Therefore, a high HDL to LDL ratio will help reduce the chances of atherosclerosis. Exercise tends to increase the amount of HDL in the body while smoking has the opposite effect. It should be noted that heredity plays a role in determining your ratio of HDL to LDL. How can you change your own lifestyle to decrease the chances of atherosclerosis?

View the video titled *Healthy Choices, Healthy Hearts*, Alberta Heart and Stroke Foundation and answer the following question. This video may also be obtained through the Learning Resources Distributing Centre.

22. The risk factors that have been identified in the video increase the risk of heart disease. Based on these risk factors, what habits would you retain in your lifestyle and what could you change to minimize your risk of dying from heart disease?

Check your answers by turning to the Appendix, Section 1: Activity 3.

**DID YOU KNOW?**

Alberta physicians and engineers have worked together to develop two new cutting tools for clearing arteries and have used a technology called laser-induced fluorescence to precisely pinpoint the location of plaque in the arteries. This technology has made angioplasty and bypass surgery safer for individuals.

In this activity you have studied the structure of arteries, veins, and capillaries. The structure of these vessels is directly related to their various functions. They play a major role in ensuring proper transport of nutrients to the cells of the body and proper transport of wastes away from the cells. Harmful substances, such as surplus cholesterol, may enter the circulatory system and have an adverse influence on health. Your health is dependent on what you do, what you eat, and the way you handle stress. You play a vital role in determining your own health!

# Activity 4: A Bloody Affair

Have you ever wondered why physicians request blood tests? What are they able to find out about you by looking at your blood? The previous activity had you learn about the structure and function of the blood vessels. In this activity you will investigate the composition and function of the components of human blood tissue. You will examine the role of blood as a tissue in transporting gases, nutrients, and wastes throughout the body.

**tissue** – a group of similar cells performing a similar function

What is blood composed of? Blood is a liquid substance containing a number of important chemical structures. By definition, blood is a **tissue**. It may seem odd that a liquid substance can be considered a tissue, but it is. In human adults, there is about 5.5 L of blood circulating throughout the body. To learn more about the composition of blood, read pages 13 and 15 of *Visions 3* and answer the following questions.

Visions

1. What does blood consist of?
2. Identify a major type of cell found in the blood.
3. List two noncellular components found in the blood.
4. Define the term *plasma*.
5. What are the major components of plasma and what is the percentage of each component?

6. Nutrients, wastes, gases ($O_2$ and $CO_2$), and hormones are given as components of plasma. What does this suggest as some possible functions for plasma?

Check your answers by turning to the Appendix, Section 1: Activity 4.

## Investigation: Observing Blood Cells

**PATHWAYS**

If you have access to a microscope with a 100X oil immersion objective and prepared slides of blood cells, do Part A. If you do not have access to these materials, do Part B.

## Part A

Do Activity 1.2 on pages 13 and 14 of *Visions 3*.

### Purpose

Observe blood cells using a microscope and prepared slides.

### Materials

- light microscope
- immersion oil
- prepared slides of blood cells

### Procedure

**Step 1:** Read the planning section of this activity carefully and study Skill 2 and Skill 3 in Appendix A of your textbook.

**Step 2:** Follow the procedure given in Activity 1.2 on page 14.

### Observations

You should see red blood cells and white blood cells similar to those shown in the Appendix for question 8 of Part B (Slides 1 and 2). Your scale will depend on the type of microscope you are using.

### Analysis and Interpretation

7. Answer Textbook questions 1 to 8 from the Analysis and Interpretation section of Activity 1.2 in *Visions 3*.

Science Skills
- [ ] A. Initiating
- [x] B. Collecting
- [x] C. Organizing
- [x] D. Analysing
- [x] E. Synthesizing
- [ ] F. Evaluating

## Part B

### Purpose

Identify blood cells and blood cell components.

### Background Information

Read the background information found in the folder before viewing each microslide.

### Materials

- microslide viewer
- microslides—set 95, Human Blood

### Procedure

**Step 1:** Follow the instructions as outlined in the folder to load your slides. Copy the slide blanks from question 8 in the Observations.

**Step 2:** View Slide 1. On your observation sheet, draw and label a platelet, a red blood cell (RBC), and a white blood cell (WBC). Record their magnification. Note: In the microslide red blood cells are referred to as red corpuscles.

**Step 3:** View Slide 3. Note the three types of white blood cells (stained) and their functions as given in the Background Information for Slide 3 on the folder. Also compare the size of the white blood cells to the size of the red blood cells.

**Step 4:** View Slide 2—Electromicrograph. Draw a red blood cell at this high magnification showing its biconcave shape. Record its magnification.

**Step 5:** View Slide 7—Sickle Cells. Draw the appearance of three abnormal sickle red blood cells.

### Observations

8. Copy the following and draw in the spaces what you have observed in each slide. Write in the magnification.

Slide 1—Human Blood Smear

magnification: _____

Slide 2—Red Blood Cells

magnification: _____

Slide 7—Sickle Red Blood Cells

magnification: _____

## Analysis and Interpretation

9. From examining the blood smear in Slide 1, which blood cell is in the highest proportion in blood?

10. State the major function associated with each of the following blood components:

    a. red blood cells

    b. white blood cells

    c. platelets

11. What is the advantage of the red blood cell having a biconcave shape?

12. State two structural differences between red blood cells and white blood cells.

13. What is the significance of red blood cells not having a nucleus?

Check your answers by turning to the Appendix, Section 1: Activity 4.

Now that you have a good idea about what blood is, it's time to discuss the role of blood as a tissue in transporting gases, nutrients, and wastes throughout the body.

The transport of gases through the body is essential to the living state. Do you know what the two main gases are? If you answered oxygen and carbon dioxide, you're absolutely right.

14. How does oxygen get into your body?

Now, the next question to ask is why you need oxygen to live. Oxygen is required by all the cells in your body to produce energy to maintain life. The process through which this energy is produced is called cellular respiration. The following is the general equation for cellular respiration.

glucose + oxygen → carbon dioxide + water + energy

Using the preceding information and information from previous courses, do the following questions.

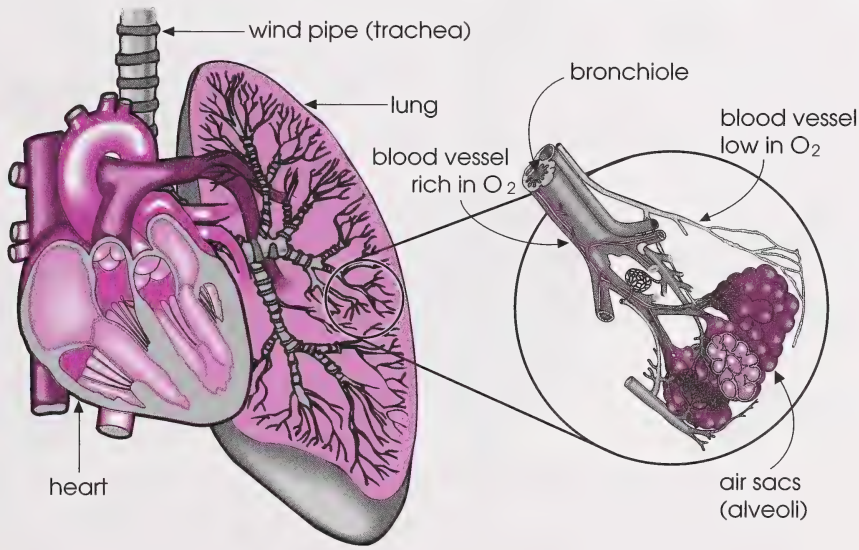
15. What organelle in the cell is responsible for energy production?

16. Through which process does carbon dioxide get produced and how does this gas get removed from the body?

Visions

Once you breathe in the air containing oxygen gas, how does it reach the cells of your body? How does carbon dioxide get from the cells to the lungs? The answer is the circulatory system. To learn more about the transport of oxygen and carbon dioxide, read pages 15 to 17 of your text and answer the following questions.

17. Identify the location of gas exchange in the lungs.




18. Through what process does oxygen and carbon dioxide get transported between the bloodstream and the tissues?

Visions

19. Do Checkpoint question 1 found on page 23 of your text.

Check your answers by turning to the Appendix, Section 1: Activity 4.

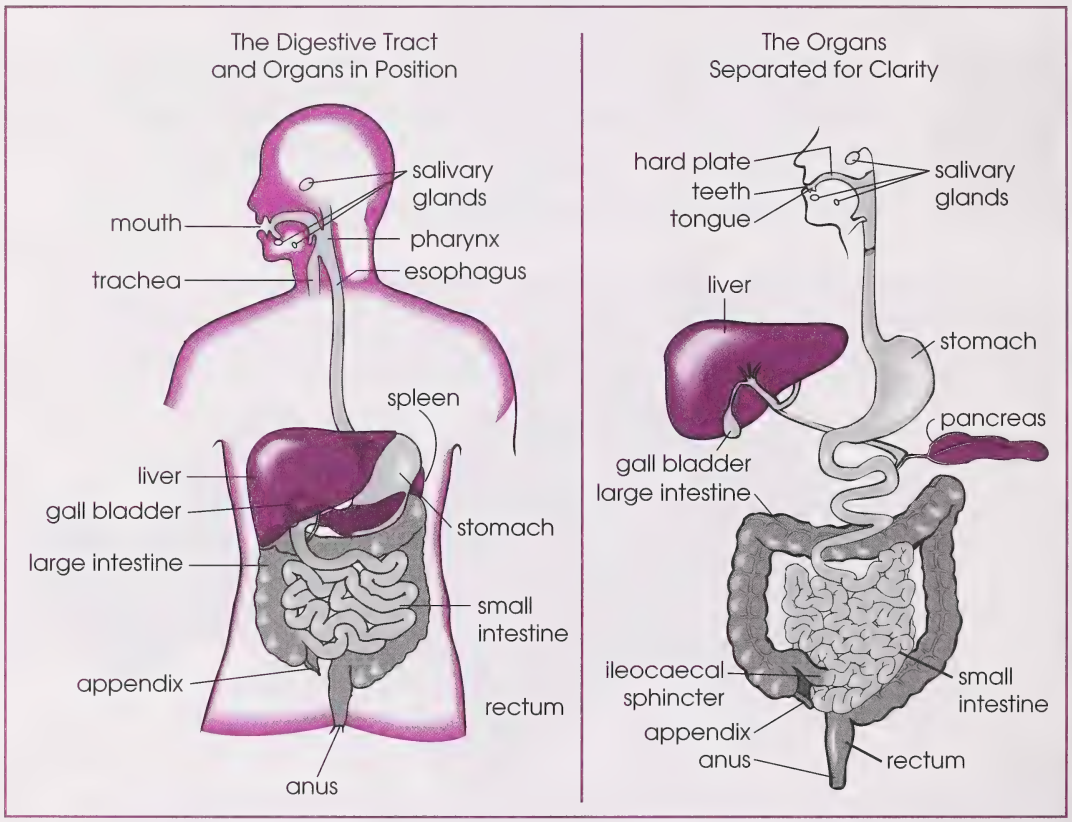
Visions

Besides being involved in the transport of gases, blood also plays an important role in the transport of nutrients and wastes. To learn more about this transport, read pages 17 to 19 of your text and answer the following questions.

20. State the purpose of digestion.

21. Where in the body does most of the digestion process take place?

The following graphic of the digestive system shows the location of the small intestine in relation to the rest of the digestive system.




22. In which digestive organ do most of the nutrients get transported into the bloodstream?

**DID YOU KNOW?**

The small intestine is located below the ribcage and measures 5.5 to 7 m in length. The small intestine does not get its name from its length but from the smaller diameter it has compared to the large intestine.

23. Identify two key processes used to transport nutrients into the bloodstream.

24. State the purpose of villi in the small intestine.

25. What vessels absorb the majority of fat?

**IMPORTANT NOTE**

The role of blood is to transport nutrients to the cells of the body and transport wastes from the cells of the body.

26. Once the nutrients enter the bloodstream, they travel to the liver via the hepatic portal vein. State the general function of the liver.

27. State six essential functions of the liver.

**DID YOU KNOW?**

The liver is responsible for performing over 500 functions in the body! Because it is capable of so many different functions, scientists do not think a machine could do its work.

28. State the effect of excessive alcohol consumption on the liver.

Check your answers by turning to the Appendix, Section 1: Activity 4.

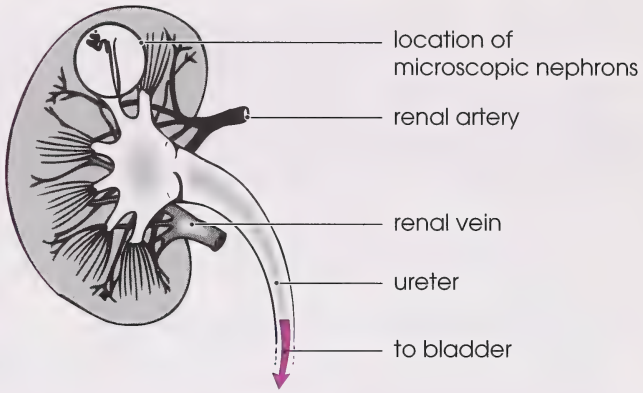
**homeostasis** – maintaining equilibrium or balance

Visions

Like the liver, the kidneys are also involved in the processing of blood. They are involved with the removal of waste materials produced by the cells of the body. How do the waste materials get from the cells to the kidneys? If you said by way of the blood you're right again! The kidneys are very important in maintaining equilibrium or **homeostasis** in the body. They will maintain the proper amounts of materials in the blood by either causing more to enter the bloodstream, if there is not enough, or remove excess, if there is too much. To find out more about the kidneys, read pages 18 and 19 of your text and answer the following questions.

29. Identify the processing units in the kidney.

A longitudinal section through the kidney




30. Blood flows into each nephron through a ball of capillaries known as the _____.

31. The first part of the nephron that receives materials from the glomerulus is called _____ capsule.

32. Identify two substances that enter the nephron and can be put back into the bloodstream.

33. The waste products leaving the collecting tubules of the nephron will form _____.

It is important to note that without a normal functioning pair of kidneys, various chemical substances could build up in the body and reach a concentration where they would become toxic.

Check your answers by turning to the Appendix, Section 1: Activity 4.

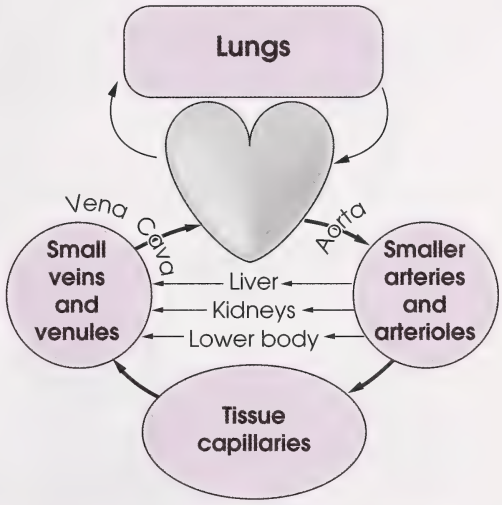
View the video titled "Circulatory and Respiratory System," *Human Body Series*, National Geographic, ACCESS Network, 1988. Answer the questions that follow. This video may also be obtained from the Learning Resources Distributing Centre.

34. How does blood entering the right side of the heart differ from blood entering the left side?

35. Describe the interrelationship that exists between the respiratory and circulatory systems.

Science Skills
- [ ] A. Initiating
- [ ] B. Collecting
- [ ] C. Organizing
- [x] D. Analysing
- [ ] E. Synthesizing
- [ ] F. Evaluating

36. Use the video definition to circle the sections of the diagram which represent the systemic and pulmonary circuits. Label the circuits.



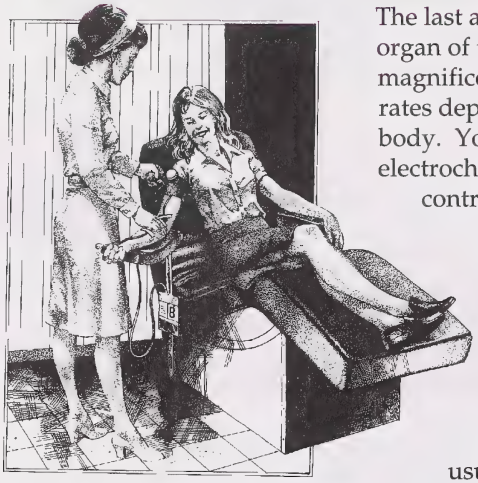

Check your answers by turning to the Appendix, Section 1: Activity 4.

The major function of blood is to transport materials throughout the body. Besides gases, nutrients, and wastes, the blood plays a vital role in assisting in the delivery of prescription drugs to their sites of action. Once the drug is swallowed, it is broken down by the digestive system and absorbed into the bloodstream. In the bloodstream, the drug will travel to its site of action via the blood and perform its duty. Without the circulatory system, it would be more difficult for drugs to reach their sites of action. Because of greater difficulty, this would mean that it would take more time for the drug to reach its destination and would decrease the drug's effectiveness.

Blood transfusions have become an important issue over the past few years. There has been a growing concern about transfusions containing infected blood. Certain diseases such as hepatitis and acquired immune deficiency syndrome (AIDS) can be passed on through blood transfusions. Because of this growing concern, some individuals have donated their own blood and specified that it be used for transfusions for specific individuals, such as immediate family members. However, with increased precautions regarding blood screening, blood transfusions are quite safe. Another possibility, though not used regularly, is to use artificial blood. Artificial blood may be transfused into anyone requiring blood and will not carry hepatitis or AIDS. However, artificial blood is still not like the real thing. With advances in medical technology, artificial blood may be developed to the degree that it can be like the real thing!

In this activity you have examined the role of blood as being a major transporter of gases, nutrients, and wastes. You have investigated the components of blood and their respective functions. Blood and its components serve as connectors between all the parts of the body. Without these connections, the body would not be able to maintain a state of equilibrium. As you can now see, your blood is not a simple red liquid—it is a complex fluid containing cells and many dissolved substances. By examining blood, physicians can determine if your body is functioning normally. In the next activity the regulation of the circulatory system will be discussed.

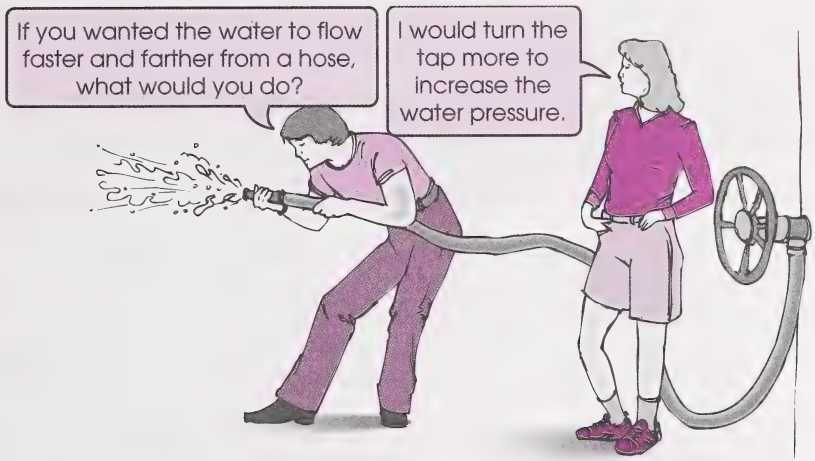
## Activity 5: Control Mechanisms



The last activity in this section will return to the major organ of the circulatory system—the heart. This magnificent structure is able to pump blood at various rates depending on the requirements of the cells in the body. You will research the chemical and electrochemical homeostatic regulatory mechanisms controlling cardiac output and blood pressure.

Cardiac output refers to the amount of blood pumped through the ventricle per minute. Two factors which influence cardiac output are heart rate (how many beats/minute) and the strength of the heartbeat. When you are involved in a strenuous physical activity, your cardiac output will usually increase because your heart will beat faster and harder.

Blood pressure refers to the pressure put on the walls of the blood vessels as blood passes through them.


If you wanted the water to flow faster and farther from a hose, what would you do?
I would turn the tap more to increase the water pressure.

What organ plays a role in controlling your blood pressure? If you said your heart, you're right. Since the heart can vary its beat and strength, it influences blood pressure. Two important points should be noted about blood pressure. First, blood pressure varies throughout your body. The pressure in your arm may be different than in your legs. Second, the minimal blood pressure is that which allows the blood to flow from your heart, throughout your body, and back to your heart again.

**Visions**

To learn more about the regulation of cardiac output and blood pressure, read the section titled The Circulatory System Is Under Dynamic Controls on pages 19 and 20 of your text and answer the following questions.

1. Blood flow to other systems varies with activity. Explain what this means.

2. Identify two control mechanisms used to maintain equilibrium or homeostasis with regards to cardiac output and blood pressure.

3. Design a flow chart to describe the nervous control mechanism to restore cardiac output and blood pressure **after** strenuous exercise. Hint: How does the body reduce cardiac output and blood pressure?

**TO HELP YOU REMEMBER**

Think about a water hose with the tap turned to certain level; to decrease the pressure in the hose, you would increase the diameter of the hose. You would decrease the diameter of the hose to increase the pressure.

4. What structure in the body plays a hormonal role in maintaining proper blood pressure? Describe two effects of the hormone angiotensin II.

Check your answers by turning to the Appendix, Section 1: Activity 5.

Another hormone that affects your circulatory system is adrenaline. This hormone increases the rate and strength of your heart beat. When you are frightened or in an emergency situation, you will have experienced the effects of adrenaline. Now that you have a better idea of how your circulatory system is controlled, it's time to investigate the actions of the heart and changes in blood pressure due to different types of activities.

## Investigation: Cardiac Output and Blood Pressure

Science Skills
- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☐ F. Evaluating

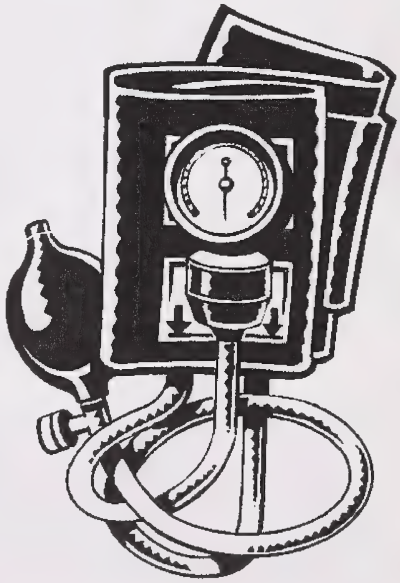
### Purpose

Become familiar with the procedure associated with measuring pulse rate and blood pressure. Investigate the role of exercise in influencing cardiac output and blood pressure.

### Background Information

Visions

Read Skill 4 on page 470 in Appendix A of *Visions 3* on using a sphygmomanometer (sfig-mo-ma-NOM-et-er) to measure blood pressure. Normal blood pressure ranges for individuals aged sixteen to twenty-four years will be 105 to 140 for the systolic pressure, while the diastolic may be between 60 to 88. The pulse rate is a measure of the heart rate. It may be taken at the side of your neck (carotid artery) or the inside of your wrist (radial artery). Normal resting pulse rates may range between 70 to 100 beats per minute.



**PATHWAYS**

If you have access to a sphygmomanometer, do Part A. If you do not have access to this instrument, do Part B.

## Part A

### Materials

- a partner
- stethoscope
- sphygmomanometer
- clock or watch with a second hand

### Procedure

For the best results, carry out the following procedure with a partner.

**Step 1:** Ask your partner to sit quietly for one minute.

**Step 2:** After one minute has passed, measure your partner's blood pressure (systolic/diastolic).

**Step 3:** Measure your partner's pulse rate for fifteen seconds and multiply this value by four to determine the rate for one minute.

**Step 4:** Repeat steps 1 to 3 while your partner is in a standing position and then in a lying position.

**Step 5:** Have your partner run hard on the spot for one minute.

**Step 6:** At the conclusion of one minute, immediately take his/her blood pressure and pulse rate.

**Step 7:** After three minutes of rest, repeat measurements for blood pressure and pulse rate.

### Observations

5. Make and record your results in a table similar to the following one.

| Activity | Systolic Pressure (mm/Hg) | Diastolic Pressure (mm/Hg) | Blood Pressure (systolic/ diastolic) | Pulse Rate (beats/min) |
|---|---|---|---|---|
| Sitting | | | | |
| Standing | | | | |
| Lying | | | | |
| Running (taken immediately) | | | | |
| Three minutes after running | | | | |

### Analysis and Interpretation

6. Describe how posture (sitting, standing, lying) affects pulse rate.

7. Describe how exercise affects blood pressure and pulse rate. Explain.

8. How did the blood pressure and pulse rate readings taken three minutes after running differ from those taken immediately after running?

9. Are there people with particular characteristics whose pulse rate and blood pressure return to normal much more quickly than others? Why do you think this happens?

Check your answers by turning to the Appendix, Section 1: Activity 5.

## Part B

### Materials

- a partner
- clock or watch with a second hand

## Procedure

Do Part A omitting any steps requiring blood pressure readings (do pulse rate).

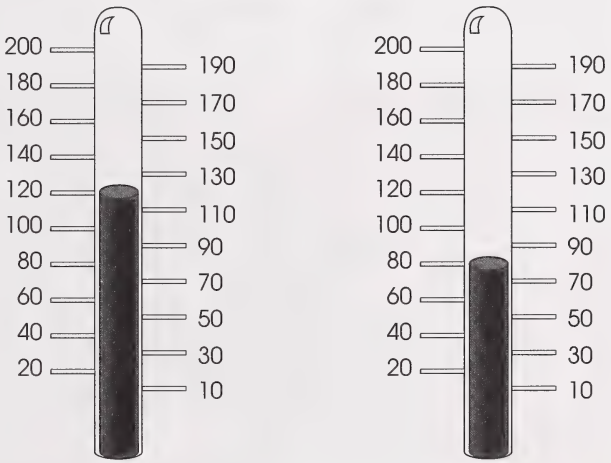
## Observations

10. Make and complete a chart to record pulse rate for each activity described in Part A.

## Analysis and Interpretation

11. Answer question 6 and questions 7 to 9 as they pertain to pulse rate only from the Analysis and Interpretation section of Part A.

12. What would your blood pressure be if your doctor recorded the following readings on a sphygmomanometer?




Check your answers by turning to the Appendix, Section 1: Activity 5.

## High Blood Pressure (Hypertension)

Visions

Your body is capable of maintaining normal blood pressure within certain limits. If blood pressure reaches a certain high value, the body may not be able to restore it. This results in individuals with high blood pressure.

Read the paragraphs on high blood pressure found on pages 20 and 21 in your text. After reading, answer the following questions.

13. List three effects of high blood pressure on the body.

14. What systolic and diastolic values would indicate a person with high blood pressure? Do you have high blood pressure?

15. What happens to your chances of getting high blood pressure as you get older? Why?

16. Identify two possible symptoms associated with high blood pressure.

Check your answers by turning to the Appendix, Section 1: Activity 5.

The reading on pages 20 and 21 of your text indicates that lifestyle changes and medications can be used to control high blood pressure. With respect to lifestyle changes, the following factors can contribute to high blood pressure.

| Factor | How Blood Pressure Is Affected |
|---|---|
| Body mass | Increased body mass requires more blood and blood vessels to supply all areas with blood. The heart must work harder to circulate blood throughout the body, increasing blood pressure. |
| Physical activity | Increased heart rates during exercise result in increased blood pressure. Exercise can, however, strengthen the heart making it more efficient. A more efficient heart will beat less often when a person is resting, resulting in lower blood pressure. |
| Stress | Your heart rate increases, muscles tense, and blood pressure increases. Prolonged stress or tension can lead to high blood pressure. |
| Smoking | Chemicals in cigarette smoke are absorbed into your bloodstream. These chemicals cause a reduction in the diameter of your blood vessels, increasing blood pressure. |

People with high blood pressure may restore their blood pressure to normal levels by making the necessary adjustments to their lifestyle whether it be weight control, exercise, stress reduction, and/or changing smoking habits. If the necessary lifestyle changes are not made, individuals may be provided with medications to lower their blood pressure and keep it under control.

**DID YOU KNOW?**

The life expectancy of a 35 year old with slight hypertension (high blood pressure) may be reduced from 73 to 55 years. (Alberta Stroke and Heart Foundation statistic)

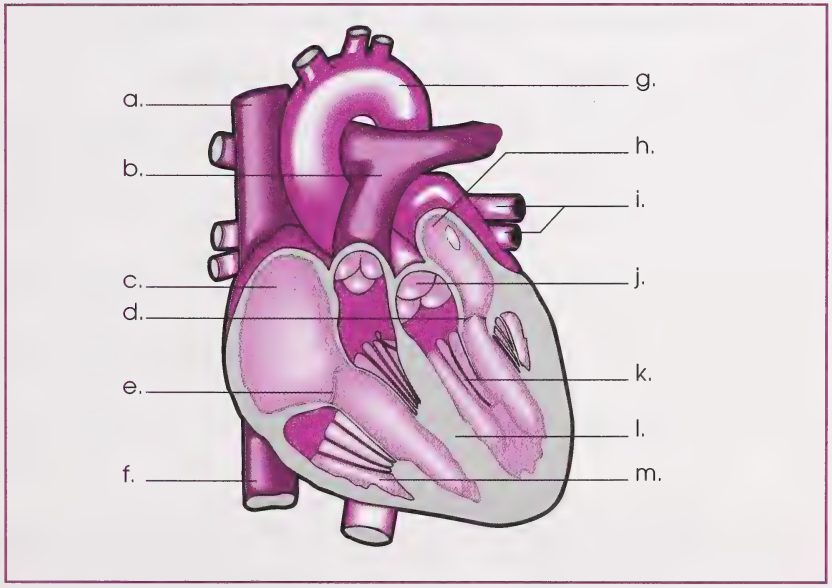
# Follow-up Activities

If you had difficulty understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

## Extra Help

Do the following questions to review important concepts from Section 1.

1. Identify the following parts of the heart and the blood vessels associated with it.



2. For each of the following structures, put them in order based on the sequence of blood flow and state whether the structure contains oxygenated or deoxygenated blood. The first one is done for you.

a. 1 superior and inferior venae cavae deoxygenated

b. _____ pulmonary artery _____

c. _____ right atrium _____

d. _____ aorta _____

e. _____ left atrium _____

f. _____ pulmonary veins _____

g. _____ left ventricle _____

h. _____ right ventricle _____

3. Match the following terms with the correct statement:

• artery • vein • capillary

a. _____ This directs blood towards the heart.

b. _____ Diffusion of nutrients and oxygen to body cells occurs here.

c. _____ This directs blood away from the heart.

d. _____ This carries oxygenated blood most of the time.

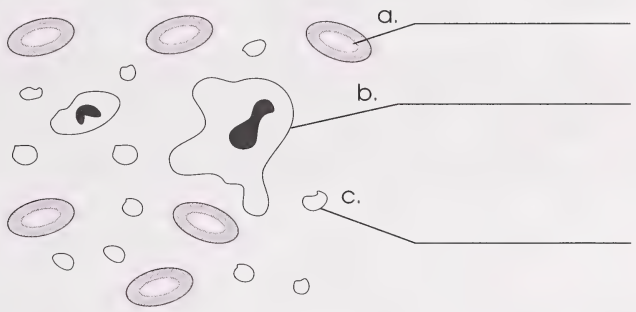
e. _____ This contains one-way valves that allow for one-way flow.

f. _____ This has the thinnest walls.

g. _____ This has elastic, thick walls.

h. _____ This carries blood under high pressure.

4. Identify the various components of blood in the diagram on the right and give their main function. Also indicate which component is usually in the greatest quantity.




5. Fill in the blanks in the following paragraph.

When you are involved in strenuous exercise, your _____ rate increases to bring more oxygen into your body and your _____ rate increases to send more oxygen to your cells by way of the bloodstream. The circulatory system is kept under control by two mechanisms. With respect to the _____ mechanism, specialized nerve endings called _____ initiate nerve impulses that are sent to the _____ of the brain. This part of the brain will interpret the situation and determine whether to increase or decrease the activity of the heart along with blood pressure. With respect to _____ control, the two hormones involved are _____, which causes the strength and rate of the heartbeat to increase, and _____, which causes an increase in blood pressure.

Check your answers by turning to the Appendix, Section 1: Extra Help.

## Enrichment

Do one or more of the following activities.

1. If you have access to a heart from a school or packing plant in your area, you may perform a dissection. Handle the scalpel with care. The procedure for the dissection involves the following steps.

   **Step 1:** Place the heart ventral side up (more rounded side). The apex (pointed part at the bottom of the heart) consists entirely of the left ventricle. Note that with a ventral view, what appears on your left side of view is really the right side of the heart and vice versa.

   **Step 2:** Before making incisions, attempt to identify the chambers of the heart along with the blood vessels present in your specimen. Note the relative thicknesses between chambers and various blood vessels.

   **Step 3:** Begin the incisions by cutting through the right atrium down through the tricuspid valve into the right ventricle. Once you reach the bottom of the right ventricle, cut up towards the pulmonary artery. If done correctly, you should have performed a cut which appears like a "V."

   **Step 4:** Carry out a similar series of incisions for the left side of the heart. Cut through the left atrium down through the bicuspid valve into the left ventricle. Once at the bottom of the left ventricle, cut up towards the aorta.

   **Step 5:** Study each of the chambers in the heart. Try to find the tricuspid valve and biscuspid valve. See if you can follow the flow of blood as given in question 2 of Extra Help. Once you've completed the dissection, dispose of the heart appropriately.

2. Do Think questions 1 to 7 found on pages 33 and 34 in the textbook.

3. Hemophilia is an inherited disease in which the blood-clotting process is disrupted. People with hemophilia are in danger of bleeding to death even if only slightly injured. Research the treatment that is available to hemophiliacs.

4. You may want to visit a Red Cross Blood Donor Clinic and donate blood if you are over seventeen years of age. Natural human blood and blood products are always needed for transfusion.

5. If you have access to a laser videodisc player and the laser videodisc entitled *The Living Textbook: Life Science* (Side 2), Perceptile Inc., view the section on blood components and functions.

6. View the video *Homeostasis: The Sea Within*, T.V. Ontario, ACCESS Network, 1984. The video includes animation and graphics covering homeostatic processes. It defines extracellular fluid (ECF) and intracellular fluid (ICF) plus the processes of osmosis, diffusion, exocytosis, endocytosis, and active transport.

Check your answers by turning to the Appendix, Section 1: Enrichment.

## Conclusion

In this section you have examined the circulatory system, a system which enables the human body to interact with its environment. You have studied the structure and function of the circulatory system; including the heart, arteries, veins, and capillaries; and the path of blood circulation. You have investigated the structure and function of blood and its components. Lastly, you should have gained an understanding of the hormonal and nervous mechanisms controlling the heart and blood pressure. In the next section you will study in greater depth a major function of the circulatory system—that of protecting against infection and disease.

Assignment Booklet

**ASSIGNMENT**

Turn to your Assignment Booklet and do the assignment for Section 1.

Section

# 2 Defence! Defence!

[1]

David, the boy in the photograph, was born without an immune system, the body system used to ward off infection and disease. Therefore, he had to live in a "plastic bubble" which was free of any germs. Could you imagine being like David? Since germs are always in the air, you can understand why he had to live in a bubble.

In this section you will study the defence mechanisms in your body that protect you from disease and infection. In the first activity you will examine the nonspecific defence mechanisms, specifically the role of the skin. In the second activity you will learn more about blood by studying the cellular and noncellular components of the human immune system, the internal specific defence mechanisms. Finally you will gain an appreciation for blood types and why only certain types of blood can be transfused into your body.

[1] Baylor College of Medicine/Peter Arnold, Inc.

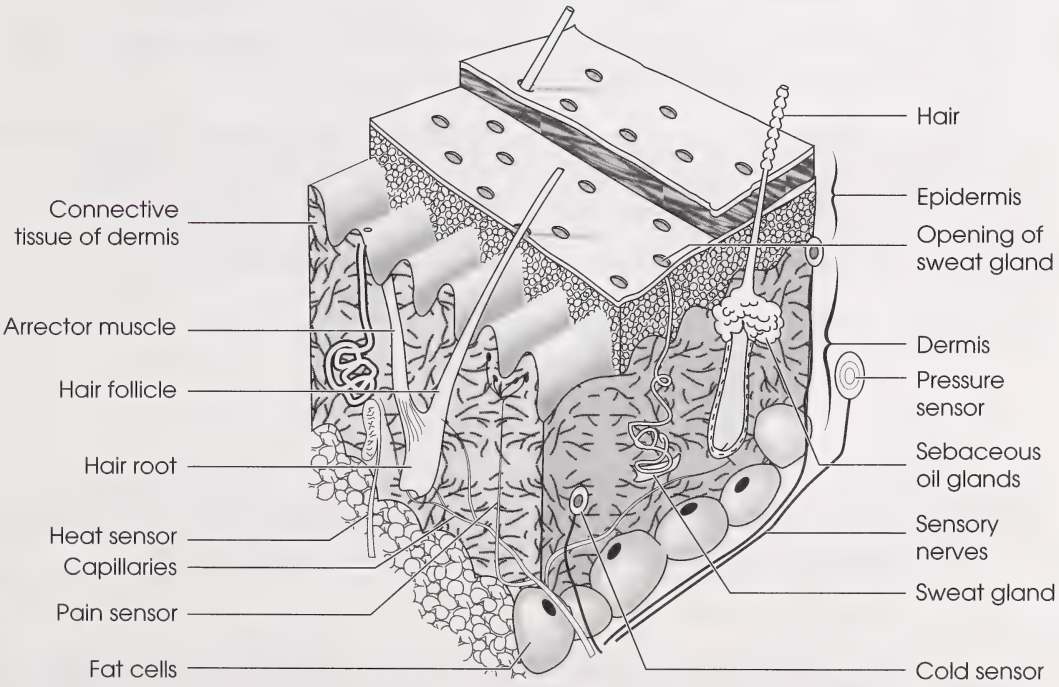
# Activity 1: Nonspecific Defence Mechanisms

Do you know which is the largest organ in the body? What did you guess? The lungs, liver, heart, or stomach? Actually, the largest organ in the body is your skin! Yes, your skin is considered an organ. In this activity you will find out more about your skin and how it acts as the first line of defence. Besides the skin, other nonspecific defence mechanisms you will learn about include the mucous membranes and white blood cells.

What are nonspecific defence mechanisms? Nonspecific defence mechanisms are those which are general in their action. In other words, they will attempt to protect your body no matter what the infectious agent is. With respect to nonspecific defence mechanisms, the first line of defence is the skin and mucous membranes, while the second line of defence refers mainly to the process of **phagocytosis** by white blood cells.

**phagocytosis** – process by which cells engulf non-cellular particles

At first glance the skin seems like a simple covering. However upon closer examination, it is much more complicated than it looks. It consists of two major layers, the epidermis and the dermis. Within the dermis, a whole array of structures may be found.



1. With reference to the skin diagram, list an example or examples of the following structures:

   a. sensors  b. cells  c. nerves  d. glands

**DID YOU KNOW?**

The surface area of a person's skin is about 1.75 $m^2$ and has a mass of approximately 3 kg.

Visions

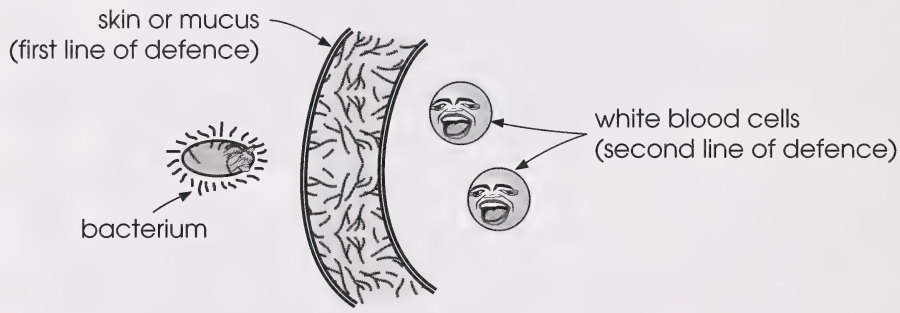
Now that you have seen that the skin is not as simple as it looks, it's time to examine its role as a defence mechanism as well as looking at other nonspecific lines of defence. Read pages 24 and 25 of your text and answer the following questions.

2. Describe three ways the skin is able to protect your body from infection.

3. Describe how foreign materials that are swallowed or breathed in are removed from the body.

If infectious agents are able to penetrate the first line of defence and get into the body, the second line of defence is there to greet them.

4. What are macrophages and neutrophils and what process are they capable of?




5. What role does a fever play with respect to protecting your body against infection?

6. Where in the body are all blood cells produced? From what type of cell do all blood cells come from?

Check your answers by turning to the Appendix, Section 2: Activity 1.

Another part of the nonspecific defence mechanisms includes the inflammatory response. Damage to tissue by injury, either through a cut or entry by an infectious agent, triggers the inflammatory response. Small blood vessels in the area of the injury dilate or expand resulting in an increased blood flow. The capillaries in this region also release more materials into the tissues. The overall result is a swelling or inflammation and redness in this injured area. Have you ever experienced the inflammatory response?

**DID YOU KNOW?**

The pus that is usually associated with an infected area represents dead cells and the extra fluid due to the inflammatory response.

The inflammatory response is initiated by the release of a chemical substance known as histamine which is released by another type of white blood cell. The histamine in the injured area causes the dilation of blood vessels and increased leakage from capillaries. However the most important effect of the histamine is to increase the movement of phagocytic cells to the damaged area.

**DID YOU KNOW?**

Antihistamines, which are taken to overcome hayfever or common colds, reduce the action of histamine.

7. What conclusion would you make if you saw the inflammatory response somewhere on your body?

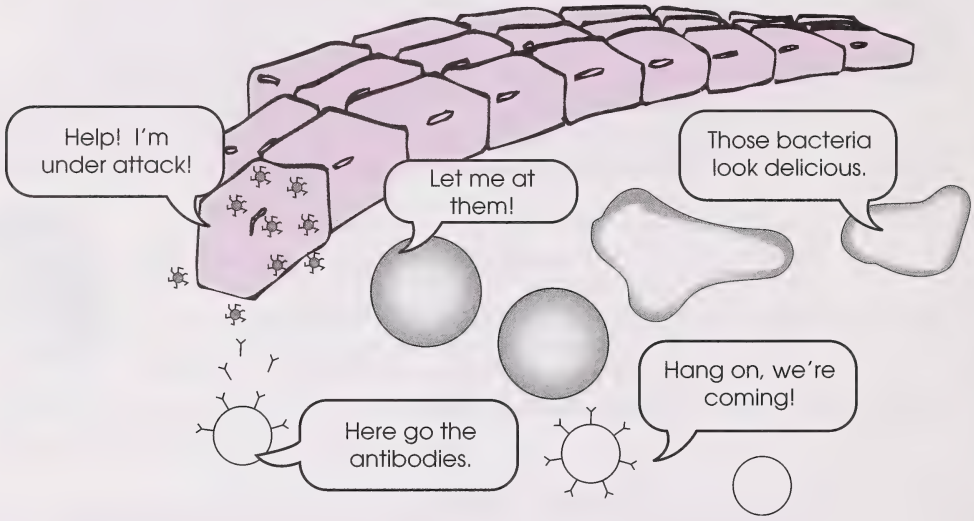
8. List three effects of histamine.

Check your answers by turning to the Appendix, Section 2: Activity 1.

In this activity you have studied the nonspecific defence mechanisms. This has involved the examination of the skin, mucous membranes, phagocytic white blood cells, and the inflammatory response. In the next activity you will learn about the specific defence mechanisms, namely the human immune system.

## Activity 2: Specific Defence Mechanisms

Every day your body is under attack by hundreds of viruses and bacteria. As a result, your blood mobilizes an incredible army into action. This activity will help you understand the complex events that spring the immune system into action.




If a foreign agent such as a bacteria, virus, or any other disease-causing organism is able to get through the first and second line of defence, it must deal with the powerful third line of defence—the immune system. The immune system represents the specific defence system. It differs from the nonspecific defence mechanisms in a number of important ways. First of all, it is specific in its action, which means that it is able to recognize and destroy certain foreign agents. The immune system is also able to tell the difference between foreign cells and its own cells. Another distinguishing characteristic is that the immune system has a memory. Once a foreign agent invades the body, the immune system will remember it forever and be able to better protect the body from it in the future.

1. Why would it be important for the immune system to be able to tell the difference between foreign cells and its own cells?

2. List three differences between the nonspecific defence mechanisms and the specific defence mechanisms.

Check your answers by turning to the Appendix, Section 2: Activity 2.

Now that you know something about the specific defence system, it's time to provide you with some of the finer details. When any foreign agent initiates a response by the immune system, this foreign agent is called an **antigen**. The presence of an antigen in the body will cause the immune system to produce specific proteins called **antibodies** and will also produce specialized white blood cells called **lymphocytes**. It is important to note that for every specific antigen that enters the body, a specific antibody is produced for it. For example, the chicken pox virus is an antigen that stimulates the production of an antibody specific for this virus.

3. Distinguish between the terms *antigen* and *antibody*.

Check your answers by turning to the Appendix, Section 2: Activity 2.

**TO HELP YOU REMEMBER**

Imagine yourself and all your friends to be antigens (foreign invaders) about to invade an enemy's body. Since you are all different individuals, each of you would result in the production of a specific antibody.

Also, the term ***antigen*** is a contraction of ***anti***body ***gen***erating.

**cellular immunity** – an immune response in which foreign substances are destroyed by T lymphocytes

**humoral immunity** – an immune response in which foreign substances are destroyed by antibodies

The immune response involves two possible different reactions to antigens. The response may involve the specific attack by specialized lymphocyte T cells. This type of response is known as **cellular immunity**. The other response will involve the action of antibodies. This type of response is called **humoral immunity**.

To learn more about cellular and humoral immunity, read pages 26 to 28 of your text and answer the following questions.

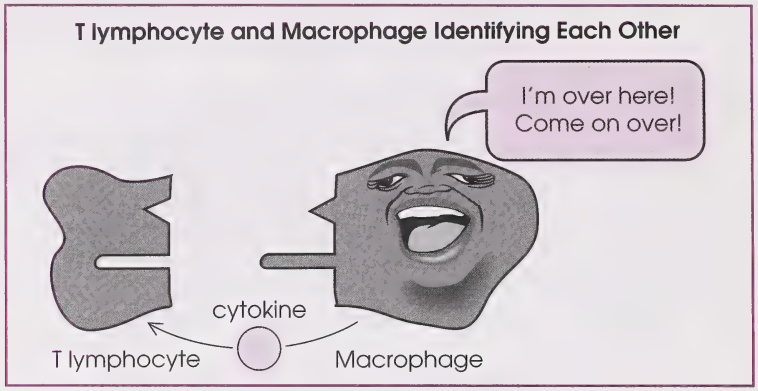
4. How does the immune system distinguish between self cells and foreign cells?

5. What type of lymphocytes are responsible for cellular immunity and where are they produced?

**T lymphocytes** – cells that recognize and destroy certain foreign substances as well as divide to form specialized immunity cells

6. Are all **T lymphocytes** the same? Explain your answer.

7. Identify the three requirements for a proper fit between a T lymphocyte and a macrophage.




It is important to note that for a T lymphocyte to be activated, it must attach to one of its own cells which have been invaded by a foreign agent. Once a proper fit has been made, T lymphocytes may divide to form other specialized cells.

8. State the function of the following types of T lymphocytes.

   a. helper T cells

   b. killer (also know as cytotoxic) T cells

   c. suppressor T cells

   d. memory T cells

9. Discuss the role of killer T cells with respect to organ transplants.

10. What type of cells does the AIDS virus attack? Discuss the significance of this.

11. What type of cells are involved in humoral immunity and where in the body are they produced?

12. What happens to B lymphocytes when activated?

13. Describe two possible consequences of antibody-antigen complexes.

14. Antibody formation in "allergic reactions" can be dangerous if not treated properly. List three possible effects of this type of reaction.

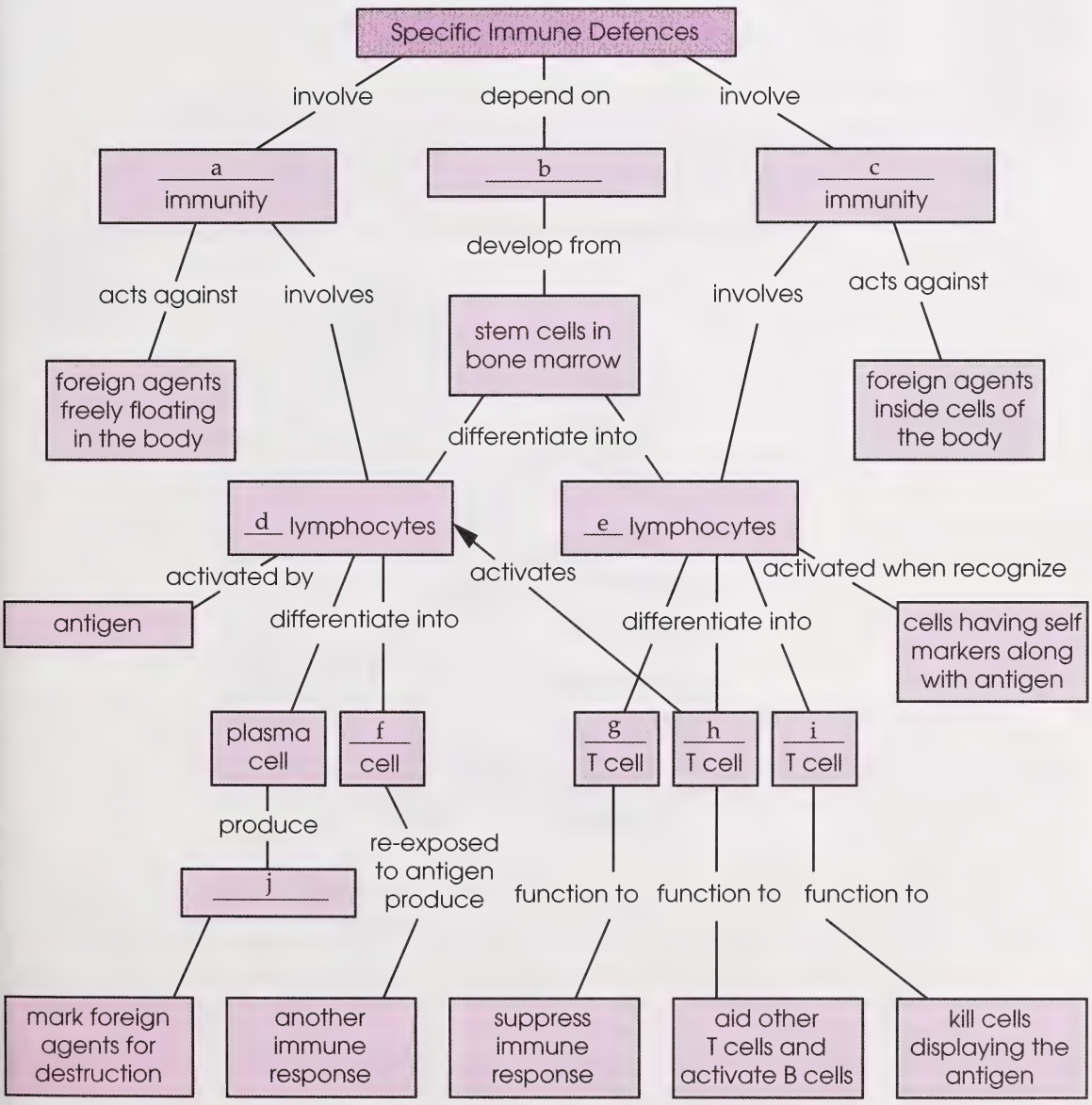
15. Define autoimmune disease.

Check your answers by turning to the Appendix, Section 2: Activity 2.

The following is a concept map. A concept map is a diagram that shows the organization of ideas and the relationship among concepts in a particular area of study. It is used to improve understanding and aid the learning process.

16. Complete the following concept map by writing the correct term for each labelled blank.

**Concept Map for the Immune Response**



The completion of the concept map should indicate to you the complexity of the immune system. It should leave you with the impression that this system does a very good job in protecting you against disease and infection.

Some diseases are so serious that the immune system has no time to respond. The victim dies first. Science and technology has used the knowledge about the immune system to develop the vaccinations. To find out some history about this process, read pages 28 and 29 in your text and answer the following questions.

**Visions**

17. Briefly describe the work of Edward Jenner.

18. Describe two major findings of Louis Pasteur with regards to immunization.

Check your answers by turning to the Appendix, Section 2: Activity 2.

Vaccines involve the injection of an inactive or weakened form of the disease-causing agent. The vaccine causes the production of antibodies, by B lymphocytes, against the specific disease-causing agent and the activation of T lymphocytes. If an individual is ever exposed to the disease-causing agent, specific antibodies and T cells will be already present in the immune system and will be able to destroy the antigen before it causes any harm. For example, when an individual receives a vaccination for smallpox, it stimulates the production for smallpox antibodies and T cells. The presence of these will protect the body if the smallpox virus ever enters the body.

Vaccines are one way to obtain immunity, but there are some diseases for which you get immune protection by experiencing the disease. For example, protection against measles is obtained once you contract the disease. Once you have had measles, you will never have to worry about getting the disease again because you have developed antibodies against it. The value of vaccinations is that it allows for the production of antibodies and T cells without suffering the effects of the disease.

19. List some diseases for which you can get vaccines.

20. What is the value of vaccinations?

Check your answers by turning to the Appendix, Section 2: Activity 2.

For an excellent review of the immune system and how it works, view the video titled *The Immune System: Your Magic Doctor*, Barr Films, 1989. This video is available through the Learning Resources Distributing Centre. Answer the following questions after you have watched the video.

21. Which cells identify the invading organism?

22. What makes the immune system so effective?

23. What do the memory T cells do?

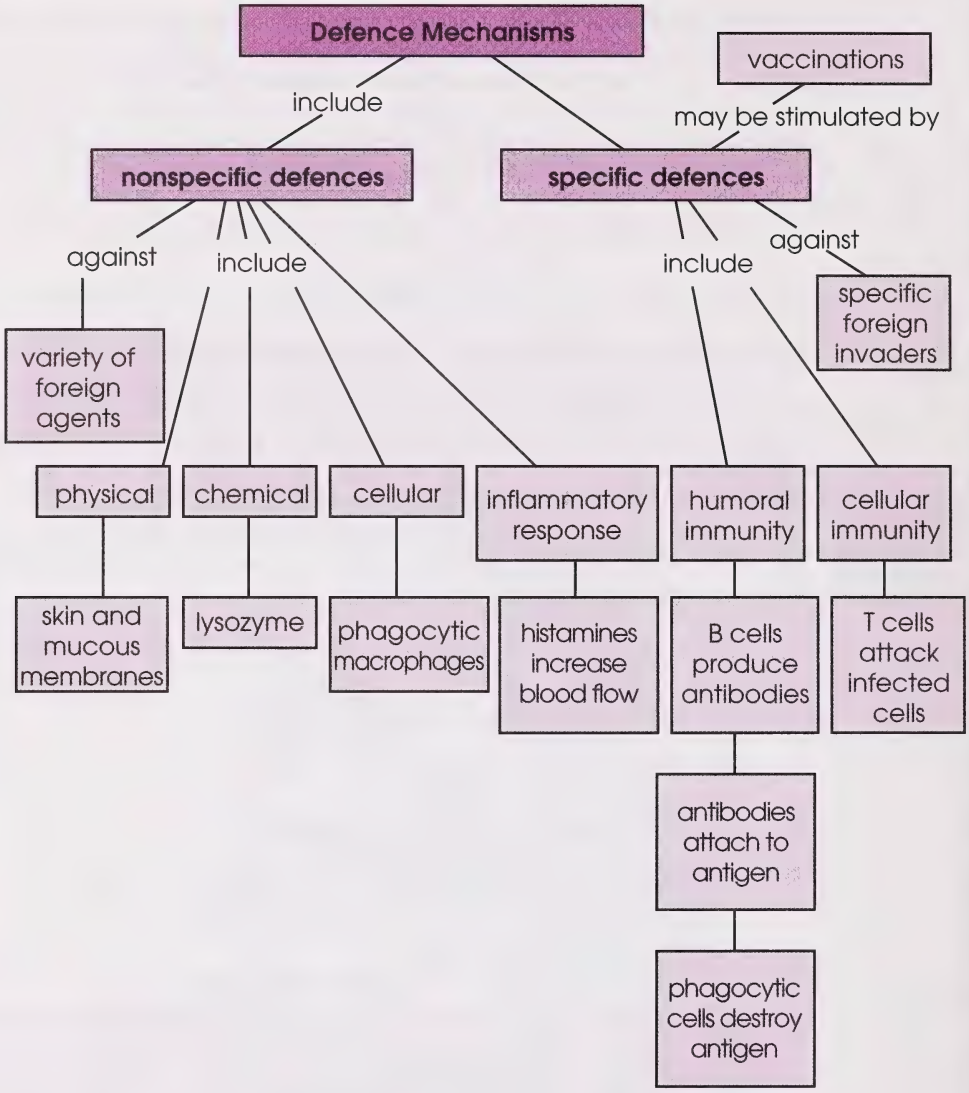
24. Which cells are destroyed by the AIDS virus?

25. Is there a specific disease caused by the AIDS virus? Explain.

26. How does immunization work?

Check your answers by turning to the Appendix, Section 2: Activity 2.

In this activity you have learned about the immune system and how it protects your body against disease. The following concept map summarizes what you should have learned in this activity. All the terms should be familiar to you.




## Follow-up Activities

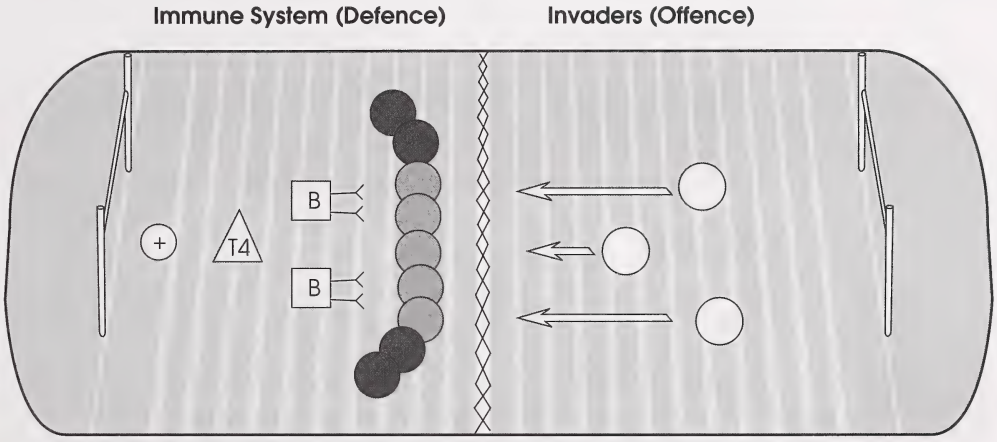
If you had difficulty understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

## Extra Help

Do the following questions to review important concepts from Section 2.

### Analogy

Imagine your body's immune system as the defensive line in a football game. This defensive line is shown on the left side of the field. The offensive line represents invading organisms—shown on the right side of the field.




The centre line represents the first line of defence.

1. What acts as the first line of defence in your body? Explain how this first line of defence works.

If the invaders get past the first line of defence, then the second line of defence is called into play and the following sequence occurs.

- The five defensive linesmen behind the line of defence are the macrophages. The macrophages engulf and eat the invaders by carrying out phagocytosis.
- The helper T cell (triangle) is the captain and instructs the defensive line to attack. The four shaded defensive backs represent the killer T cells. Their job is to tackle and bring down the opponent.
- The square cells (safeties) then begin releasing their antibodies which bind to the membranes of the intruders making them more easily eaten by the linebackers (macrophages).
- Once the battle is won, the referee (white circle with cross) who represents the suppressor T cells calls off the play.

2. Based on the preceding analogy, match each of the following lymphocytes with its role in the immune response.

| Lymphocytes | Role |
|---|---|
| a. helper T cell | i. produces antibodies |
| b. B cell lymphocytes | ii. engulfs pathogens by phagocytosis |
| c. macrophage | iii. mobilizes the lymphocytes into action |
| d. killer T cell | iv. destroys the invader |

Check your answers by turning to the Appendix, Section 2: Extra Help.

## Enrichment

Do one or more of the following.

1. Do Think questions 8, 9, and 10 on page 34 of *Visions 3*.

2. Read the bottom section of page 29 in your text on the ABO blood types. Answer Checkpoint question 5 found on page 31.

3. Read page 30 of your text on the Emergency Medical Technicians Program. Consider why you might find a career as a paramedic rewarding.

4. If you have access to a laser videodisc player and the laser videodisc entitled *The Living Textbook: Life Science* (Side 2), view the following film clips as a review of blood components. (All clips are from Chapter 13.)

   19769 Antibodies, lysis, agglutination, and phagocytosis
   Blood Types in Humans

5. Use your microslide viewer and Set 95 of the microslide entitled Human Blood to do the following investigation:

   - View Slide 3—Leukocytes. Examine the different types of leukocytes again. Note the different types of leukocytes and the function of each.

   - View Slide 4—Phagocytosis. Draw the right half of the slide showing extending pseudopodia.

- View Slide 5—Blood Type B. Draw the appearance of blood type B in type B plasma (Bp) and as it appears agglutinated in type A plasma (Ap). Record the magnification.

- View Slide 6—Fibrin. Draw the appearance of fibrin threads which form the blood clot. Record the magnification.

a. Explain why the results in Slide 5 indicate the blood tested is blood type B.

b. Describe the sequence of events in blood clotting which causes fibrin formation as shown in Slide 6?

Check your answers by turning to the Appendix, Section 2: Enrichment.

## Conclusion

In this section you have examined the defence mechanisms in your body that protect you against foreign invaders. You have studied the nonspecific defence mechanisms which act as the initial lines of defence. This includes the skin, mucous membranes, and macrophages. Invaders able to pass through the nonspecific defence mechanisms must duel with the immune system, the specific defence mechanisms. This system provides protection mainly through the activity of the B and T lymphocytes. If it was not for the immune system, many more people would be sick more often.

Assignment Booklet

**ASSIGNMENT**

Turn to your Assignment Booklet and do the assignment for Section 2.

Section

# 3 How Are Your Nerves?

PHOTO SEARCH LTD.

Have you ever touched something with your hands without knowing it was hot, like a hot pan, or a hot iron, or a hot radiator cap? How did you react? Hopefully, you pulled your hands away to prevent burning yourself. How was your body able to sense the hot object and react to it appropriately? Your nervous system plays a major role in allowing you to feel, interpret, and react properly to different environmental situations.

In previous sections you have examined the circulatory system and the defence systems in your body that help maintain a state of equilibrium. This section will look at another system involved with equilibrium—the nervous system. You will learn about the structure and function of the basic unit in the nervous system, the neuron. You will study the various sense organs and examine their role in the nervous system. You will enhance your knowledge about the organization of the nervous system into the central and peripheral nervous systems. Finally, you will investigate the reflex arc and study its functional role in the nervous system.

# Activity 1: The Neuron and the Nerve Impulse

Your nervous system functions to communicate information from one part of the body to the other. How does this information get from one place to another? The answer involves the neuron and the nerve impulse. The neuron is the structure through which information is passed by way of a nerve impulse, the information carrier.

The neuron is the structural unit of the nervous system. It is actually a single cell. To learn more about the structure and function of the neuron, carry out the following investigation.

## Investigation: The Structure and Function of the Neuron

Science Skills
- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☐ F. Evaluating

Visions

### Purpose

Study the structure and function of the nerve cell, the neuron.

### Background Information

Read pages 36 and 37 of your textbook.

1. There are nine questions in the Planning section of Activity 2.1 on page 38 of your text. Use knowledge you have gained from other courses along with other resources available to you and try to answer these questions before beginning this investigation.

Read the background information found in the microslide folder for Set 221, Nerve and Muscle Action, before viewing each microslide.

### Materials

- microslide viewer
- microslides—set 221, Nerve and Muscle Action
- blank paper and pencil

### Procedure

- Follow the instructions as outlined in the folder to load your slides.
- View Slide 1 and Slide 4.

### Observations

2. On a piece of blank paper, draw a single neuron using Slide 1 as a reference. Label the cell body, dendrites, and axon.

3. Using Slide 4 as a reference, draw and label the myelin sheath (insulating sheath), Schwann cell, and node of Ranvier.

## Analysis and Interpretation

Visions

4. Using information in the microslide folder and your text, prepare and complete a table similar to the following one.

| Structure | Function |
|---|---|
| Dendrite | |
| Axon | |
| Myelin Sheath | |
| Node of Ranvier | |

Visions

5. Read and do textbook question 3 in the Analysis and Interpretation section of Activity 2.1 found on page 39 of your text.

Check your answers by turning to the Appendix, Section 3: Activity 1.

**IMPORTANT NOTE**

A neuron is not the same thing as a nerve. Neurons are cells that make up nerves. Therefore, a nerve will contain several neurons.

Visions

Now that you have learned about the neuron, it is time to study the nerve impulse, the signal which travels through the neuron. The nerve impulse is an electrochemical signal. This means that chemicals are responsible for setting up the nerve impulse along with electric charges. To find out more about this electrochemical signal, read the section titled A Nerve Impulse Is Electrochemical in Nature found on pages 40 to 43 of your text. Answer the following questions pertaining to the reading.

6. What type of transport mechanism is involved in the sodium-potassium exchange pumps? What does this pump do? (The term *pump* is usually associated with the process of active transport.)

7. Because unequal numbers of sodium and potassium ions are moved through active transport, along with differences in permeability of $Na^+$ and $K^+$ through the membrane, different charges are set up inside and outside the membrane while it is in a resting state. What is the charge outside the membrane? What is the charge inside the membrane? What does this difference in charge set up?

8. Describe a unique property of the neuron.

9. What is an action potential?

10. Define the term *threshold*.

**TO HELP YOU REMEMBER**

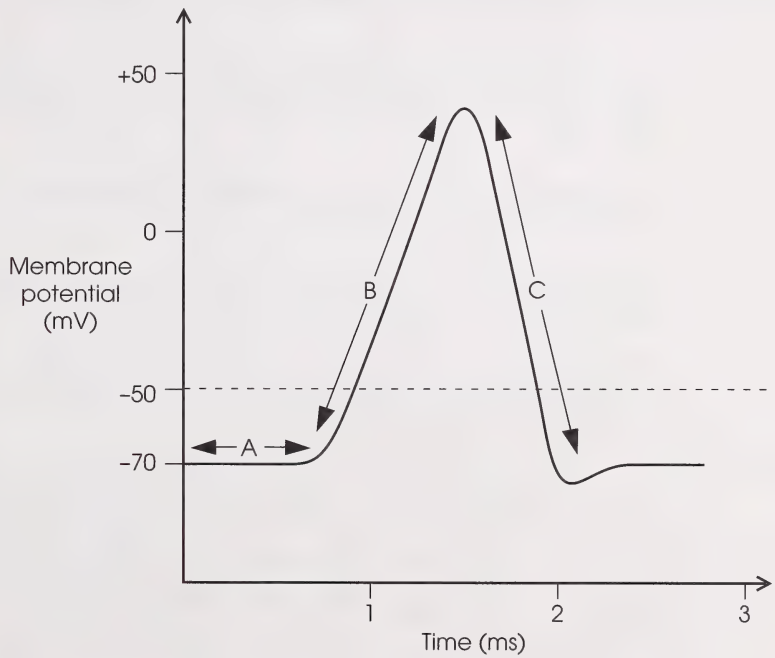
Imagine yourself having to push a large boulder over the crest of a hill to get it to roll down. The crest of the hill can be like the threshold. For you to get the boulder down the other side of the hill, you must get it over the crest. Once you do, it will roll down on its own. However, if you do not get to the crest of the hill, it will never be able to roll down the other side.

11. Once threshold is attained, there is the formation of an action potential. What ion is transported into the neuron and how does this affect the charge on the inside?

12. The following graph shows the changes in electrical charge in a neuron when an action potential occurs. Describe what is occuring at each of sections A, B, and C in terms of ion movement and identify the state of **polarity** that exists across the membrane in each section.

**polarity** – the electrical charge on the surface of a membrane due to the unequal distribution of ions on either side of the membrane

**Electrical Charge Variations During Action Potential Production**



13. State the significance of the nodes of Ranvier with respect to the transmission of the nerve impulse.

14. Why is the nerve impulse referred to as an all-or-none event?

Check your answers by turning to the Appendix, Section 3: Activity 1.

**TO HELP YOU REMEMBER**

The all-or-none response is like starting a car. You have to turn the key to a certain point to start the engine. If you don't turn the key to that point, it doesn't start. However, once you start it, it runs the same way all the time until you start driving it.

Once an action potential occurs, the nerve impulse will continue down the axon. Depolarization of one area of the membrane causes $Na^+$ ions to flow into the membrane in the adjacent area which is still polarized. This process is very similar to having a line of gunpowder and lighting it. Once it starts, it will continue as long as there is gunpowder. Did you find this difficult material to understand? Maybe a summary of the important information would help.

## Summary of Important Information on Nerve Impulses

- When the neuron is at rest, sodium-potassium active transport pumps move sodium out of the neuron and potassium in. The resting membrane is relatively permeable to $K^+$ ions, so the ions tend to leak back into the extracellular fluid by diffusion.

- This distribution of ions creates a negative charge on the inside of the neuron and a positive charge on the outside.

- An action potential is created when sufficient amounts of sodium move into the stimulated neuron and the transmembrane potential reaches the threshold level.

- The action potential results in more sodium moving into the neuron. The movement of sodium causes a reversal in charge. The inside is now positive and the outside is negative in charge.

- The action potential forms the nerve impulse which is an all-or-none response. This means that the nerve impulse fires with the same strength all the time.

- In myelinated neurons, the depolarizing action of the nerve impulse jumps from one node of Ranvier to another. This is because of the insulating ability of the myelin sheath. Therefore, nerve impulses travel faster in myelinated neurons than in nonmyelinated neurons where the impulse travels all the way down the axon.

Visions

How do neurons carry information from one neuron to the next? To find out the answer to this, read pages 43 to 46 of your text and answer the following questions.

15. What is a synapse?

16. Define the term *neurotransmitters*.

17. Refer to Figure 2.6 on page 44 of your textbook to help you to fill in the following blanks.

    _____ vesicles fuse with the axon membrane and release a _____ into the synaptic cleft (part of a synapse). The neurotransmitter _____ across the _____ and binds to special _____ molecules in the _____ membrane.

18. Once the neurotransmitter binds to the postsynaptic membrane, what are the two possible responses?

19. Copy and complete a table like the following on the stimulatory and inhibitory responses.

| | Stimulatory Response | Inhibitory Response |
|---|---|---|
| Type of ion moving ($Na^+$ or $K^+$) | | |
| Direction of ion movement (in or out of the postsynpatic neuron) | | |
| Resulting change in charge (depolarization or hyperpolarization) | | |
| Nerve impulse stimulated or inhibited | | |

20. Identify two possible consequences of neurotransmitters once they have performed their function.

21. What is acetylcholine? What is cholinesterase? State the relationship between these two substances.

22. Various chemicals can affect the functioning of neurotransmitters in the nervous system. For each of the following substances, describe its effect on the neurotransmitter and the consequence(s).

    a. curare

    b. organophosphate insecticides

    c. amphetamines

23. Describe the following disorders of the nervous system in terms of the cause and its effects.

    a. Alzheimer's disease

    b. Parkinson's disease

Check your answers by turning to the Appendix, Section 3: Activity 1.

This activity has focused on the structure of the neuron, the production of an action potential, and the transmission of information across a synapse. All of these are vital for communication within the body. In the next activity you will have the opportunity to study some of the senses, the components which help you detect information about the environment and begin the communication process.

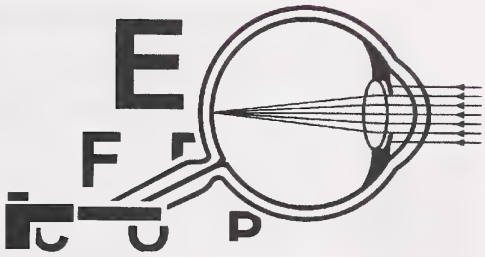
## Activity 2: Sight, Balance, and Touch

Are you sitting down right now? Take a moment and think about the environment around you. You are looking at the words on this page and interpreting their meaning. What is it that allows you to receive the message on the page? You are probably sitting down in a comfortable position. Can you feel the seat you are sitting on and your feet on the floor? What tells you which direction is up and keeps you from falling over when you walk or ride a bicycle? These abilities and sensations are due to your senses. This activity will look at the senses involved with sight, balance, and touch.

This activity focuses on receptors. Receptors are cells that when stimulated by some sort of energy (visual, sound, touch) produce a nerve impulse. Therefore, for a nerve impulse to form, a receptor must be stimulated. Your body has receptors for vision, balance, and touch.

## Visual Receptors

Information about the environment comes mainly from vision. In fact 70% of the sensations the body receives are visual. To learn more about the structure and function of the eyes, read the pages 46 and 47 and 49 to 53 of *Visions 3* and then do the following investigation.




## Investigation: Structure and Function of the Mammalian Eye

### Purpose

The purpose of this exercise is to learn the parts of the eye and their functions.

### Background Information

In the microslide folder read the introduction along with the information for Slide 1. If you have access to a model of the eye, you may use the model in place of the microslide to complete this investigation.

### Materials

- microslide viewer
- microslides—set 69, The Central Nervous System
- blank paper and pencil

### Procedure

**Step 1:** Follow the instructions as outlined in the folder to load your slides.

**Step 2:** View Slide 1—Monkey Eye.

**Step 3:** View Slide 2—Retina.

### Observations

1. On a blank piece of paper draw a diagram of the eye and label the sclera, cornea, pupil, iris, lens, retina, optic nerve, and blind spot.

## Analysis and Interpretation

2. Design a table and state the major function of each of the following structures: pupil, iris, lens, retina, and the optic nerve.

How does the lens work to focus images on the retina? To find out the answer, review Figure 2.8 on page 49 of your text.

3. Complete the following table.

| | To See Distant Objects | To See Nearby Objects |
|---|---|---|
| Ciliary Muscles (contract/relax) | | |
| Tension of Suspensory Ligaments (increased/decreased) | | |
| Shape of Lens (flattens/bulges) | | |

Check your answers by turning to the Appendix, Section 3: Activity 2.

Once the image lands on the retina it stimulates the light sensitive receptors. To learn more about these receptors, review what you saw in Slide 2 and review pages 50 to 52 in your text and answer the following questions.

4. Identify the two light receptors found in the retina. What is the general function of these receptors?

5. What vitamin is important for proper vision and what is the source of this vitamin?

**DID YOU KNOW?**

Vitamin A deficiency can lead to night blindness, a condition where individuals cannot see in dim light.

6. Distinguish between rods and cones on the basis of sensitivity to light, ability to see colour, and sharpness of vision.

Check your answers by turning to the Appendix, Section 3: Activity 2.

**Science Skills**
- ☐ A. Initiating
- ☑ B. Collecting
- ☐ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

Try the following to enhance your understanding of rods and cones. Go into a room that can become completely dark. This would work best in a room where you could gradually decrease the light in the room. First of all, view the room in the presence of light and note if you can see colour and how sharp images appear to you. Now slowly decrease the amount of light in the room until it is completely dark. Wait a few moments in the dark.

7. Record your observations as you went from a lighted area to a completely dark area. How would you interpret these observations?

Now, return to your text and continue reading about rods and cones.

8. Explain the significance of the fovea.

**DID YOU KNOW?**

You use your fovea when you need the sharpest vision. For example, you are using your fovea when you are threading a needle.

9. Refer to Figure 2.10 and attempt to find your blind spot.

   a. Where is the blind spot in the eye?

   b. Why is this region of the eye called the blind spot?

   c. What happens when you move the book closer to your eyes? Why?

10. Explain the term *colour blindness*. How does one get colour blindness?

Check your answers by turning to the Appendix, Section 3: Activity 2.

Technology has allowed for correction of vision problems. The use of eyeglasses and contact lenses has made life easier for millions of individuals. Visual problems such as myopia (near-sightedness) and hyperopia (far-sightedness) can be corrected quite easily. One of the latest technologies is the use of diamond blades or laser beams to structurally change the curvature of the cornea to restore "perfect" vision. However, this operation is expensive. Is it possible that some day corrective lenses, whether they be eyeglasses or contact lenses, will be a thing of the past? People will simply have surgery to correct their vision.

## Balance Receptors in the Inner Ear

Visions

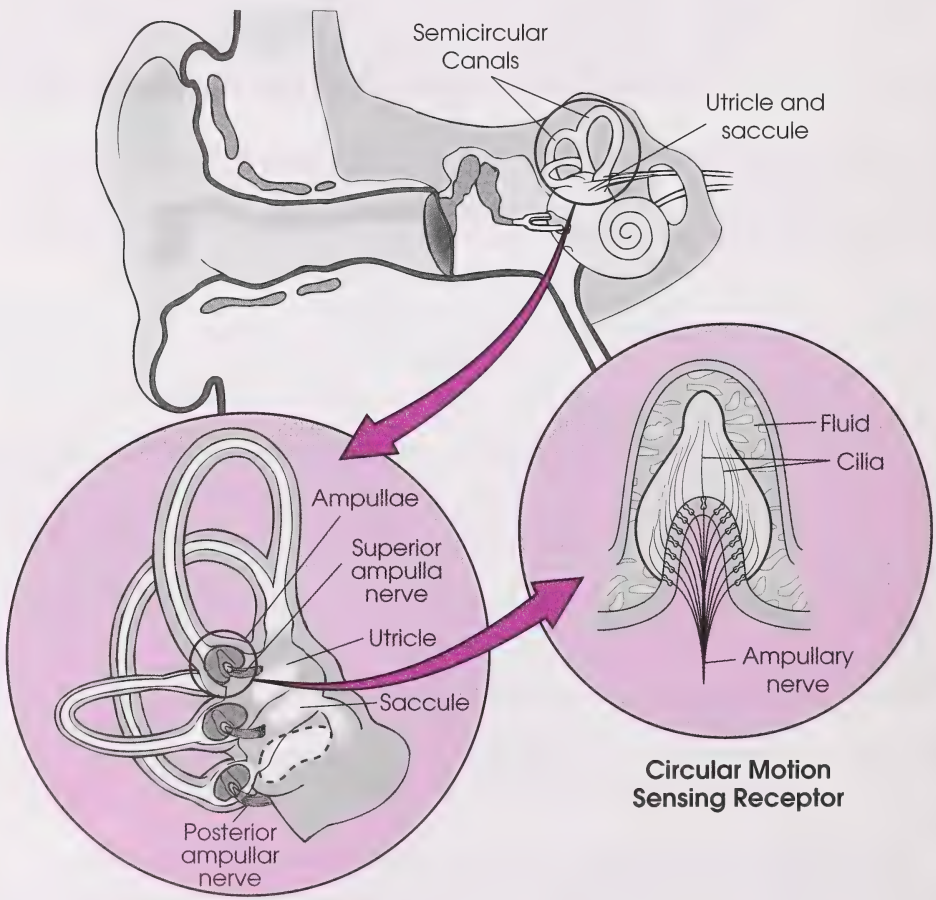
Did you know your ears have another important function besides hearing? This organ is also involved with your sense of balance. Riding a two-wheeled bicycle, walking across a balance beam, and skating are all activities requiring a sense of balance. To learn more about your sense of balance, read pages 53 and 54 of your text and answer the following questions.

11. Identify the three structures in the inner ear for detecting balance.

12. Briefly describe how these structures function?

The following diagrams show the parts of the ear related to balance and their positions in relation to the outer ear.

**Interior of Ear**




**Enlargement of Semicircular Canals in the Middle Ear**

**Circular Motion Sensing Receptor**

13. Using the information in the preceding diagrams of the interior of the ear and the information on pages 53 and 54 of *Visions 3*, explain how you feel the changing direction on a merry-go-round. You will need to recall your understanding of inertia from Science 20 to help you answer this question.

14. Which cells are responsible for creating nerve impulses?

15. Explain the phenomenon of motion sickness.

Check your answers by turning to the Appendix, Section 3: Activity 2.

To reduce the chances of motion sickness, you should make sure you get plenty of rest before a trip, eat lightly before and during the trip, get fresh air, and avoid consumption of alcohol during the trip. Drugs may also be taken to deal with motion sickness. One method employs what is called a transdermal patch. The patch is placed behind the ear and the drug is absorbed through the skin gradually. The advantage of this over taking tablets is that there is a steadier flow of medication.

How can you distinguish between the functions of the utricle, saccule, and semicircular canals? One easy way is that the utricle and saccule are involved with balance in a stationary position while the semicircular canals are involved with balance during sudden rotational movement. For example, you are running along a path and suddenly trip over something. You are able to maintain your balance and continue running. In this case, your semicircular canals are what allowed you to continue running. However, if you had taken a fall, the utricle and saccule would inform you of your head position once you had fallen.

## Touch Receptors

Receptors for touch are components you could not live without. Imagine if you could not feel your skin on a hot stove, or your body in boiling or freezing water. These receptors provide valuable information about the surroundings and give warnings of danger. To find out more about these receptors, read page 55 in *Visions 3* and answer the following questions.

16. Touch receptors are technically called mechanoreceptors. Where are these receptors located? What do these receptors respond to?

17. What is the advantage of having pain receptors in your body? Explain.

Check your answers by turning to the Appendix, Section 3: Activity 2.

Have you ever heard of phantom pain? This occurs when individuals who have lost a limb continue to feel sensations as if the missing limb were still there. For example, a man lost his leg in a car accident; when mechanoreceptors are stimulated in the stump of his leg, he gets the sensation of his toes wiggling! How can the individual feel something that is no longer there? Enquiring minds want to know! An explanation for this phenomenon will be provided to you in Activity 4.

In this activity you have had the opportunity to study some of the receptors in your body. These receptors are very important in terms of providing information about your environment. In the next activity you will learn what happens to this information once it gets into the body by examining the structure of the central and peripheral nervous systems.

## Activity 3: The Organization of the Nervous System

The organization of the nervous system allows it to work with greater efficiency. Organization is a very important characteristic. What would your room be like if it were totally disorganized? Would you be able to find things easily? Would you be able to get from one end of the room to the other relatively quickly?

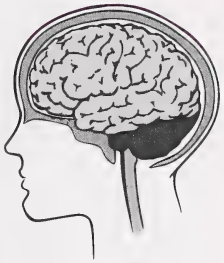
Visions

Refer to Figure 2.13 on page 58 of your text to find out more about the organization of the nervous system. Use the figure to answer the following questions. Note that in Figure 2.13 *Automatic Nervous System* should read *Autonomic Nervous System*. You may find the organization of the peripheral nervous system slightly different in some textbooks.

1. What are the two major divisions of the nervous system?
2. What are the two main parts of the central nervous system?
3. What type of neurons are found in the peripheral nervous system?
4. What are the four nervous systems found in the peripheral nervous system?
5. State the function of the central nervous system.
6. State the function of the peripheral nervous system.

Check your answers by turning to the Appendix, Section 3: Activity 3.

## The Central Nervous System (CNS)



The central nervous system is the most vital division of the human nervous system. It interprets all the data coming into it and instructs the body on how to respond. The most important part of the central nervous system is the brain.

Visions

To learn more about the brain, do the following exercise using Figure 2.14 of *Visions 3* and Side 2 of the Precise Photographic Guide of the Sheep Brain found in your loan kit. If you have access to a preserved brain, model, or computer simulation, you may use it to complete this section of the module.

Science Skills
- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

7. Draw the superior (dorsal) surface of the brain. It should be noted that dorsal means towards the back. Therefore, this view would be as if you were looking from behind. Label the cerebral cortex, cerebellum, and spinal cord.

8. Draw the sagittal section of the brain. This view is presented when the brain is sliced in half through the longitudinal fissure. In your drawing, label the cerebral cortex, cerebellum, spinal cord, corpus callosum, hypothalamus, and the medulla oblongata.

Check your answers by turning to the Appendix, Section 3: Activity 3.

Science Skills
- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

To answer the next three questions, refer to pages 60 and 61 of your textbook and microslide set 69—The Central Nervous System, and its Slide 3 information on the folder.

9. Design a table to describe the main function(s) for each of the following parts of the brain: cerebrum, cerebellum, medulla oblongata (may simply be referred to as medulla), corpus callosum, and the hypothalamus.

10. What part of the brain has undergone the greatest evolutionary changes and sets the human species apart from all others?

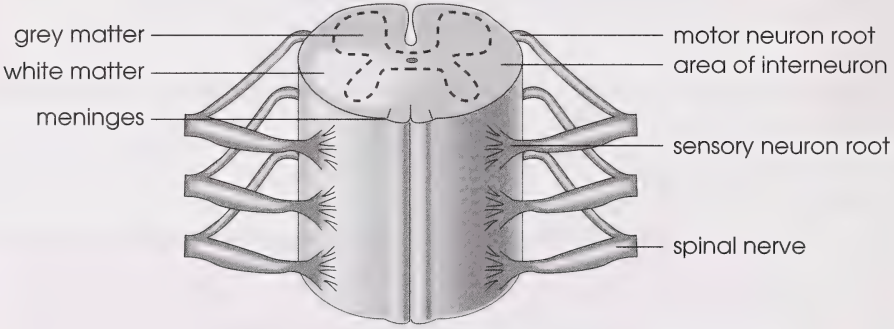
11. Describe the relationship between the hemispheres of the brain and the sides of the body each controls.

Check your answers by turning to the Appendix, Section 3: Activity 3.

## The Spinal Cord

The spinal cord is the other part of the central nervous system. Much of the information from receptors of the body travels to the spinal cord by way of nerves (remember that nerves are composed of neurons) before continuing on to the brain. However, it should be noted that the spinal cord is also capable of processing and interpreting nerve impulses. You will learn more about this when you study the reflex arc in the next activity. The spinal cord is protected by the vertebrae (which make up the backbone) surrounding it. If you were to slice the spinal cord so that a cross section was obtained, you would see the following:

**Enlarged view of spinal cord and nerves (viewed from rear)**




Visions

Notice that the spinal cord has a sensory neuron, an interneuron, and a motor neuron associated with it. The sensory neuron carries information from the receptors of the body to the spinal cord. The interneuron acts as a linking neuron between the sensory neuron and a motor neuron. See the diagram in Figure 2.15 on page 64 of *Visions 3*. Notice that this is a dorsal (rear) view of the spinal cord, while the diagram on page 64 is a ventral (frontal) view of half of the spinal cord. The motor neuron carries information from the central nervous system to the effector. The effector carries out the response and is a muscle or a gland (secretes hormones).

12. What would happen if the sensory neuron was cut?

13. What would happen if the motor neuron was cut?

Check your answers by turning to the Appendix, Section 3: Activity 3.

## Investigation: Viewing the Spinal Cord

Science Skills
- [ ] A. Initiating
- [x] B. Collecting
- [x] C. Organizing
- [x] D. Analysing
- [ ] E. Synthesizing
- [ ] F. Evaluating

### Purpose

View the spinal cord and grey matter of the spinal cord using a microslide viewer.

### Materials

- microslide viewer
- microslide set 69
- pencil and paper

### Procedure

**Step 1:** Review the information outlined in the slide folder on how to load the micro-viewer slides.

**Step 2:** View Slides 4 and 5 on microslide set 69.

**Step 3:** While viewing Slide 5, make note of the irregular-shaped cell bodies with round nuclei. These are cell bodies of neurons in the grey matter. You observed neurons as part of the nerves in a previous investigation.

### Observations

14. On a plain sheet of paper, draw what you see on Slide 4. Label the bone, canal, grey matter, and white matter.

### Analysis and Interpretation

15. What makes up the grey matter of the spinal cord?

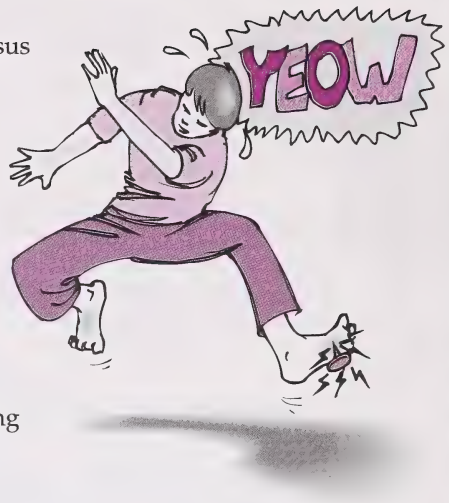
16. How many neurons are estimated to exist in the grey matter of the brain?

17. What is the estimated number of connections?

18. Why do you think so many connections are necessary?

Check your answers by turning to the Appendix, Section 3: Activity 3.

How does the central nervous system tell the difference between an emergency situation versus a nonemergency situation? For example, how can you tell the difference between stepping on a tack and stepping on a small stone while walking in your bare feet?




In Activity 1 it had been established that the nerve impulse is an all-or-none response, and therefore when it fires, it fires the same way all the time. Even though the nerve impulse is all or none, the central nervous system can distinguish situations on the basis of the number of impulses coming in per unit time and the number of neurons that are sending impulses. Therefore stepping on a tack would send more impulses per unit time and more neurons would be sending impulses.

Note the examples:
- stepping on a tack (30 impulses/s, 30 neurons stimulated)
- stepping on a stone (10 impulses/s, 5 neurons stimulated)

## The Peripheral Nervous System (PNS)

Visions

To learn more about the peripheral nervous system, read pages 64 and 65 of your text and answer the following questions.

19. Distinguish between the central nervous system and the peripheral nervous system.

20. Distinguish between location of cell bodies in sensory neurons versus motor neurons.

21. Distinguish between the somatic and autonomic nervous systems in terms of the following criteria.

| | Autonomic Nervous System | Somatic Nervous System |
|---|---|---|
| Does it control skeletal muscles or smooth muscles and glands? | | |
| Is it under voluntary or involuntary control? | | |
| Is it under conscious or unconscious control? | | |

**IMPORTANT NOTE**

Do not confuse the term *autonomic* with *automatic*. They are two different words.

22. The autonomic nervous system is divided into the sympathetic and parasympathetic nervous systems. State the general function of the sympathetic nervous system.

23. State six possible responses of the sympathetic nervous system.

Check your answers by turning to the Appendix, Section 3: Activity 3.

The sympathetic and parasympathetic nervous systems are known as antagonistic systems. This means that one system does the opposite of the other. In Figure 2.16 of your text, you can see that the actions of the parasympathetic are opposite to those of the sympathetic. It is important to note that both these systems are working all the time to maintain a state of equilibrium in your body. Your heart beats at a normal rate because of the balance between your parasympathetic and sympathetic systems. In times of stress, the effects of the sympathetic are stronger than the parasympathetic. When the emergency is over, the parasympathetic system returns your body back to a normal state.

In this activity you have looked at the organization of the nervous system. This organization is vital to its properly functioning to receive information, process it properly, and carry out a response. The organization also allows for greater specialization and efficiency, which is very important in maintaining a state of equilibrium in your body.

## Activity 4: Putting It All Together

Thus far in this section, you have learned about the structure and function of the neuron; the senses of sight, balance, and touch; along with the organization of the nervous system. In this final activity all of the pieces will be put together so that you can gain a greater appreciation for how the nervous system works as a unit in maintaining equilibrium (or homeostasis) in your body. To do this, you will learn about the reflex arc and compare the reflex arc to a normal neural response involving learning.

Visions

The simplest neural reaction is the reflex arc. The reflex arc involves a receptor, sensory neuron, spinal cord, interneuron (may or may not be involved), motor neuron, and an effector. Refer to Figure 2.15 on page 64 of your text and answer the following questions.

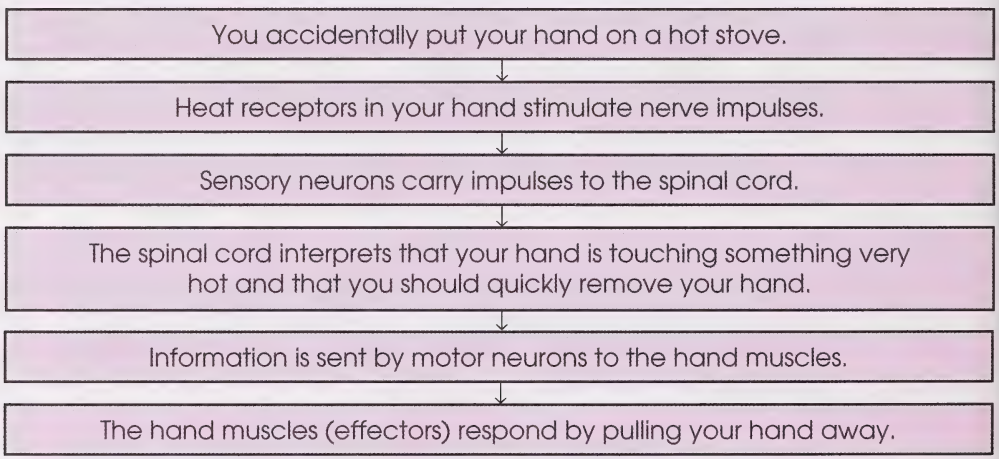
1. State the main function of each component of the reflex arc.

2. What part of the central nervous system is not involved in the reflex arc? What would be the advantage of not having this structure involved?

Check your answers by turning to the Appendix, Section 3: Activity 4.

Examples of reactions involving the reflex arc include the knee-jerk reflex and the withdrawal reflex. The knee-jerk reflex is important in preventing you from falling when your knee buckles. An example of the withdrawal reflex is when you pull your hand away from a hot stove. You can see why it would be important to react very quickly in these types of situations. The following flow chart illustrates how your body would respond in a typical withdrawal reflex.

**Example of Withdrawal Reflex**


You accidentally put your hand on a hot stove.
Heat receptors in your hand stimulate nerve impulses.
Sensory neurons carry impulses to the spinal cord.
The spinal cord interprets that your hand is touching something very hot and that you should quickly remove your hand.
Information is sent by motor neurons to the hand muscles.
The hand muscles (effectors) respond by pulling your hand away.

Now that you know what the reflex arc is, how does this differ from a normal neural response? To help you answer this question, perform the following investigation.

## Investigation: Comparing Reflexes and Learned Neural Responses

Science Skills
- ☐ A. Initiating
- ☑ B. Collecting
- ☑ C. Organizing
- ☑ D. Analysing
- ☑ E. Synthesizing
- ☐ F. Evaluating

### Purpose

The purpose is to design experiments to study human reflex action and compare this reflex action to a neural response involving learning.

## Materials

- a partner
- plastic or wooden ruler (about 30 cm long)
- paper and pencil

## Procedure

You will be doing two experiments in this investigation. The procedural steps for each experiment are in a scrambled sequence. After putting the steps in the correct order, complete the investigation.

3. To practise the science skill of designing experiments, put the steps in the correct order.

**Pupillary Reflex**

**Step 1:** Compare the size of both pupils after your partner has opened the closed eyelid.

**Step 2:** Record your observations.

**Step 3:** Ask a partner to close one eyelid for about one minute.

**Step 4:** Ask your partner to open the closed eyelid.

**Reaction Rate**

**Step 1:** Have a partner rest his or her arm on a table with the wrist and hand over the edge.

**Step 2:** Record your measurement.

**Step 3:** Measure the distance the ruler fell before being caught.

**Step 4:** Repeat the preceding steps four more times for the hand and do the same for the other hand. Therefore, you are doing five trials for each hand. Design a table to record all of your results and calculate an average for each hand.

**Step 5:** Inform your partner that you will release the ruler sometime in the next fifteen seconds.

**Step 6:** The partner must catch the ruler between his or her thumb and forefinger when it is released.

**Step 7:** Place the ruler just above the thumb and index finger. Place the 1 cm side of the ruler closest to the thumb and index finger. The thumb and index finger should be about 4 cm apart.

## Observations

4. Record your observations for the pupillary reflex and the reaction rate experiments.

## Analysis and Interpretation

5. Identify the manipulated variable for the pupillary reflex.

6. Identify the responding variable in both experiments.

7. State two controlled variables for the reaction rate experiment.

Visions

Refer to the bottom section of page 62 of your text for the next two questions.

8. What is the difference between a reflex and a response?

9. Identify the pupillary reflex as a true reflex or a response. Do the same for the reaction rate experiment. Explain your answer.

Check your answers by turning to the Appendix, Section 3: Activity 4.

## Application

Do you remember the concept of phantom pain discussed in the previous activity? How is the individual able to have the sensation of wiggling toes without having toes? The answer is that the sensation is due to the activity of the brain. Therefore, when receptors in the stump of the leg were stimulated, they initiated nerve impulses which travelled to the central nervous system. Through memory, the brain interpreted these impulses as wiggling toes. This resulted in the person having the sensation of wiggling toes! This raises an important point which is that sensations do not come from the area of stimulation but from the brain!

Modern technology has done much in the area of nerve diseases and nerve problems such as severed nerves. To learn more about what is being done, read the following sections in your textbook and answer the questions that follow.

Visions

- Restoring the Senses—page 56

  Restoring the Senses presents technological advances in an attempt to restore vision and movement.

- Dr. Stephen Hawking—page 63

  Dr. Stephen Hawking presents an inspirational biography of an individual who has a neurological disorder, which has not deterred him from living a "normal" life and doing some great things in science.

- Careers in Physical Rehabilitation—page 66

  Careers in Physical Rehabilitation discusses the various occupations involved in helping people rehabilitate so that they can lead as normal a lifestyle as possible.

10. What is the major difficulty in reconnecting severed nerves?

11. What are the resulting effects of Lou Gehrig's disease?

12. Dr. Stephen Hawking has been battling Lou Gehrig's disease for over thirty years. Which muscles in particular must be functioning?

13. Do Textbook question 3 on page 71 of *Visions 3*.

14. A satisfying career depends on job satisfaction. What satisfaction might you get from a career in physical rehabilitation?

Check your answers by turning to the Appendix, Section 3: Activity 4.

View the video "Nervous System," *The Human Body Series*, National Geographic, ACCESS Network, 1988. This video may be purchased from the Learning Resources Distributing Centre. Familiarize yourself with the following questions first. Then as you view the video, answer the questions. Stop the tape whenever necessary.

15. What is the function of the nervous system?

16. Describe the basic organization of the nervous system.

17. Outline the sensory input to Sharon's brain as she takes the peach out of the picnic basket.

18. Complete the following chart that relates sensory receptors to the site of interpretation.

| Sensory Receptor | Cerebral Cortex Lobe |
|---|---|
| olfactory cells | |
| | occipital |
| hair cells in ear | |
| | frontal |

19. Describe the comparison between Jim's brain and a computer.

20. Compare the involuntary control of the autonomic nervous system and the cerebellum.

Check your answers by turning to the Appendix, Section 3: Activity 4.

In this activity you have investigated the reflex arc and the learned response. By looking at these two neural reactions, you have had the opportunity to see how the nervous system works and how communication takes place. Information about your environment is sensed by the receptors of your body, information is sent to be processed, and appropriate responses are made to restore or maintain equilibrium in your body.

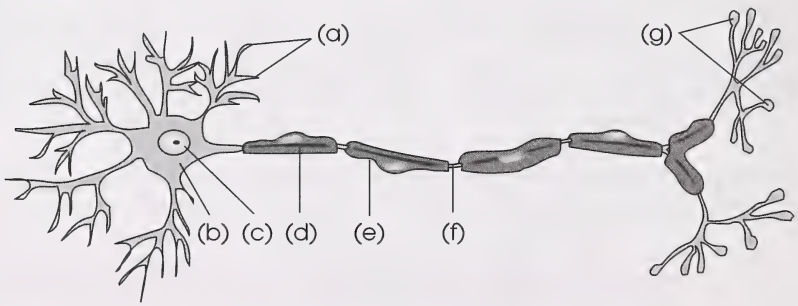
# Follow-up Activities

If you had difficulties with the activities in this section, it is recommended that you do the Extra Help. If you have a clear understanding of the main ideas and had few difficulties with the activities, it is recommended that you do the Enrichment.

## Extra Help

Do the following questions to review important concepts from Section 3.

1. Label the following parts of a motor neuron.




a. _____ e. _____

b. _____ f. _____

c. _____ g. _____

d. _____

2. Select the term that provides the best match for each of the descriptions that follow.

| | | |
|---|---|---|
| a. sodium ions | e. synapse | i. axon |
| b. potassium ions | f. hyperpolarization | j. dendrite |
| c. node of Ranvier | g. action potential | k myelin sheath |
| d. neurotransmitters | h. threshold | l. presynaptic membrane |

_____ an extension of cytoplasm that carries nerve impulses away from the cell body

_____ the fatty covering over the axon that acts as an insulator

_____ series of events forming a nerve impulse

_____ minimal stimulation to create an action potential

_____ ions that move into the neuron to create a nerve impulse

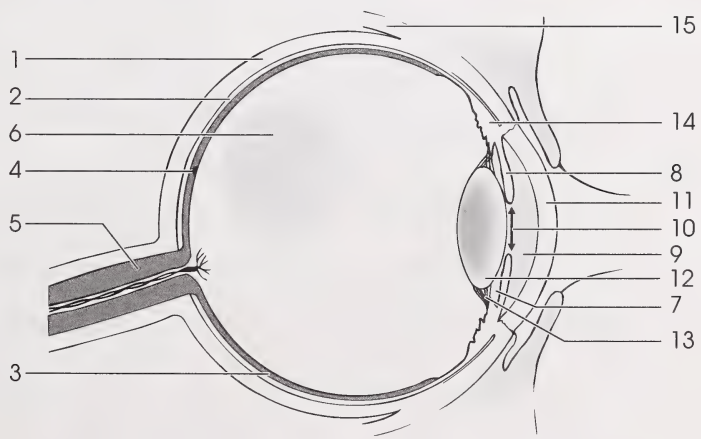
_____ chemical substances that diffuse across to the postsynaptic membrane

_____ gap between neurons or between neurons and effector

_____ structure of the neuron that receives information

3. Specialized cells that are stimulated by changes in the environment and initiate nerve impulses are called _____.

4. Use the following diagram of the eye and match the function with the proper number.



_____ a. responsible for focusing the image

_____ b. controls the opening and closing of the pupil

_____ c. layer that contains the rods and cones

_____ d. carries impulses from the eye

_____ e. part of the retina that gives the sharpest images

5. _____ cells are more sensitive to light than _____ cells.

6. a. Where are the structures responsible for balance found?

   b. List the three major structures involved with this process.

   c. Identify the specific receptor cells in these structures.

7. Touch receptors are located in the _____ and are called _____ because they respond to stretching or to _____.

8. For each of the following statements or terms, indicate whether it represents the central nervous system (NCS) or the peripheral nervous system (PNS).

   _____ a. brain

   _____ b. autonomic nervous system

   _____ c. sensory neurons

   _____ d. spinal cord

   _____ e. parasympathetic nervous system

   _____ f. somatic nervous system

9. The somatic, autonomic, parasympathetic, and sympathetic nervous systems all contain both _____ and _____neurons.

10. Read each of the statements concerning the central nervous system and identify each as being true (T) or false (F).

    _____ a. The thinking part of the brain is known as the cerebellum.

    _____ b. The medulla oblongata controls vital reflexes like heart rate and breathing rate.

    _____ c. The cerebrum sets the human species apart from all others.

    _____ d. The spinal cord is not capable of processing information.

    _____ e. The spinal cord is made up of sensory and motor neurons.

    _____ f. The structure joining the two hemispheres of the brain is called the hypothalamus.

11. The _____ nervous system is responsible for responses to emergencies and stress.

12. What does the following pathway represent?

    stimulus → receptor → sensory neuron → spinal cord → motor neuron → effector

Check your answers by turning to the Appendix, Section 3: Extra Help.

## Enrichment

Do one of the following activities.

Visions

1. At the beginning of the chapter, on pages 36 and 37 of *Visions 3*, there was a brief discussion on cerebral palsy. Research this disease and write a report on it. Information may be obtained from the Cerebral Palsy Association.

Calgary Cerebral Palsy Association
103 St. Gregory Junior High
5310 – 26 Avenue, S.W.
Calgary, Alberta
T3E 0R6
Tel: (403) 246-3111

Edmonton Cerebral Palsy Association
7 Princeton School
7720 – 130 Avenue
Edmonton, Alberta
T5C 1Y2
Tel: (403) 476-2344

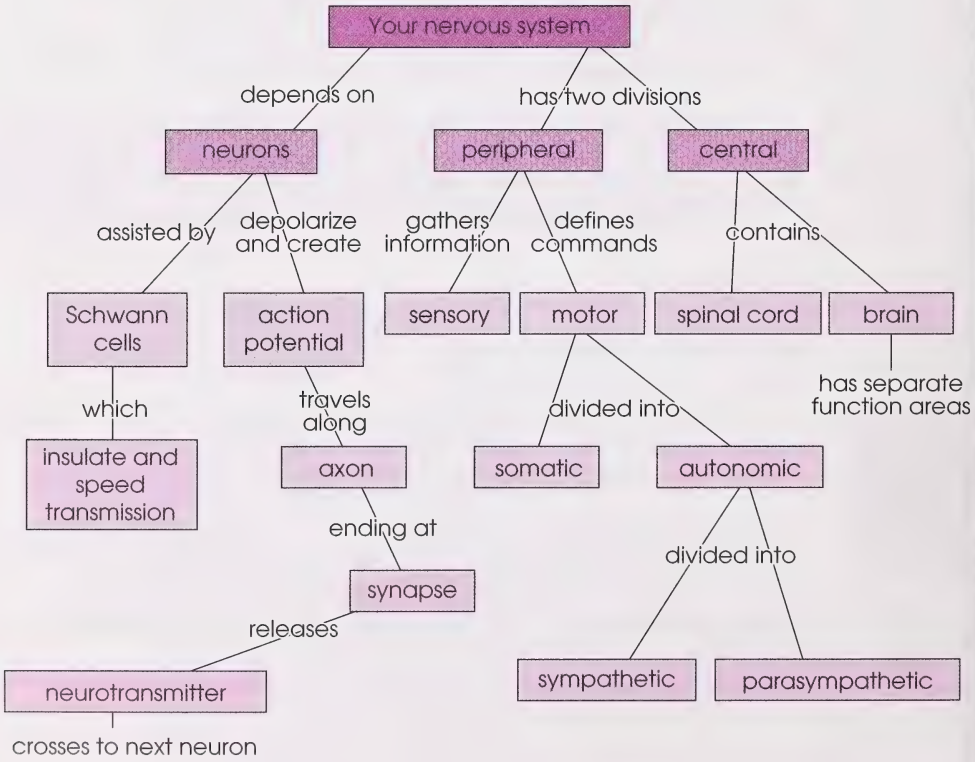
Visions

2. Do Think questions 1, 4, 5, 7, and 8 found on pages 69 and 70 of your text.

Check your answers by turning to the Appendix, Section 3: Enrichment.

## Conclusion

At the beginning of this section there was a photograph showing a person removing a hot pan from an oven. After completing this section you should have a good idea of how your nervous system would respond to touching a hot pan without protection. You should have learned about the structure of the neuron and the formation of a nerve impulse. You have studied various receptors in the body and their role in detecting changes in the environment. You have examined the organization of the nervous system and seen how this contributes to its efficiency. Finally, you have compared a reflex arc with a learned response. The nervous system is vital for finding out information about the environment, interpreting the information, and carrying out appropriate responses. This sequence of events is what allows your body to maintain a state of equilibrium. The following concept map highlights the major factors in your nervous system.



Assignment Booklet

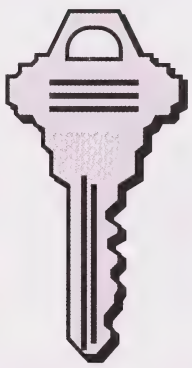
**ASSIGNMENT**

Turn to your Assignment Booklet and do the assignment for Section 3.

# MODULE SUMMARY

This module focuses on the mechanisms living organisms use to maintain equilibrium with the environment, using the human organism as a model system. There were three major concepts developed in this module. The first concept was that the circulatory system enables the human body to interact with its environment. The second concept was that the human body has defence mechanisms to protect itself from disease-causing organisms and adverse environments. The third concept is that the nervous system mediates the interaction of humans with their environment. In working through this module, you should have gained a greater appreciation of your own body and how it works.

# Appendix




Glossary

Science Skills

Suggested Answers

Science Data Booklet

# Glossary

**antigen:** any foreign substance which initiates a response by the immune system

**antibody:** a protein substance which searches out specific foreign invaders and aids in their destruction

**cellular immunity:** an immune response in which foreign substances are destroyed by T lymphocytes

**homeostasis:** maintaining equilibrium or balance

**humoral immunity:** an immune response in which foreign substances are destroyed by antibodies

**lymphocytes:** specialized white blood cells involved with the immune response

**phagocytosis (ˌfag-ə-sə-ˈtō-səs):** process by which cells engulf non-cellular particles

**polarity:** the electrical charge on the surface of a membrane due to the unequal distribution of ions on either side of the membrane

**stem cells:** unspecialized cells which give rise to specialized cells such as blood cells

**system:** a collection of linked objects, cells, or processes

**tissue:** a group of similar cells performing a similar function

**T lymphocytes:** cells that recognize and destroy certain foreign substances as well as divide to form specialized immunity cells

---

\a\ **h**at \ā\ **a**ge \ä\ **b**arn \ch\ **ch**in \e\ l**e**t \ē\ b**e**, pretty \er\ c**are** \ėr\ t**erm** \f\ **f**, tele**ph**one \g\ **g**o, **g**ive \i\ **i**s \ī\ **i**ce \j\ **j**am, **g**iant \k\ a**cc**laim, see**k** \ng\ lo**ng** \o\ h**o**t \ō\ **o**pen \ȯ\ **o**rder, d**oo**r \oi\ **oi**l, b**oy** \ou\ **ou**t \s\ **s**ay, pea**c**e \sh\ r**sh** \th\ **th**in \TH\ **th**en \u\ c**u**p \ů\ f**u**ll \ü\ r**u**le, m**o**ve \yü\ **u**se \y\ **y**et \z\ **z**ero \zh\ mea**s**ure, sei**z**ure \ə\ **a**bove, pill**a**r, take**n**, under, penc**i**l, tap**i**r, lem**o**n, fav**o**ur, circ**u**s, measure.

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# A Framework for Scientific Problem-Solving Skills*

* This information is provided by Alberta Education, Evaluation Branch

## A. Initiating and Planning

- identify and clearly state the problem or issue to be investigated
- differentiate between relevant and irrelevant data or information
- assemble and record background information
- identify all variables and controls
- identify materials and apparatus required
- formulate questions, hypotheses and/or predictions to guide research
- design and/or describe a plan for research or to solve the problem
- prepare required observation charts or diagrams

**B. Collecting and Recording**

- carry out and modify the procedure if necessary
- organize and correctly use apparatus and materials to collect reliable experimental data
- accurately observe, gather, and record information or data according to safety regulations (e.g., WHMIS) and environmental considerations

**C. Organizing and Communicating**

- organize and present data in a concise and effective form (themes, groups, tables, graphs, flow charts, and Venn diagrams)
- communicate data more effectively, using mathematical and statistical calculations where necessary
- express measured and calculated quantities to the appropriate number of significant digits and use appropriate SI units for all quantities

**D. Analysing**

- analyse data and information for trends, patterns, relationships, reliability, and accuracy
- identify and discuss sources of error and their effect on results
- identify assumptions, attributes, bias, claims, or reasons
- identify main ideas

**E. Connecting, Synthesizing, and Integrating**

- predict from data or information
- formulate further testable hypotheses supported by the knowledge and understanding generated
- identify alternatives for consideration
- propose and explain interpretations or conclusions
- develop theoretical explanations
- relate the data to laws, principles, models, or theories identified in background information
- answer the problem investigated
- summarize and communicate finding
- decide on a course of action

**F. Evaluating the Process of Outcomes**

- establish criteria to judge data or information
- consider consequences and perspectives
- identify limitation of the data and information, interpretations, or conclusions as a result of the experimental/research/project/design, processes, or methods used
- suggest alternatives and consider improvements to experimental technique and design
- evaluate and assess ideas, information, and alternatives

# CRITERIA FOR ASSESSING SCIENTIFIC PROBLEM-SOLVING SKILLS

## A. Initiating and Planning

| Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|
| • Proposes a simple problem statement when initiated to do so | • Proposes a simple problem statement | • Proposes a problem to be investigated | • Clearly states the purposes and problem to be investigated | • Performs at a level beyond level 4 |
| • Background information must be supplied | • Background information is supplied from teacher or student's own experience | • Background supplied by teacher, reference material, or student's own experience | • Prepares the necessary background information from references, research, discussion, and/or past experience | • Characteristic of work done at college or university level |
| • Identifies those things that change and those that stay the same | • Identifies variables and controls | • Identifies controls, manipulated variables, and responding variables | • Identifies the controls and variables | |
| • Guesses about the outcomes | • Makes 'educated' guesses | • Makes a prediction and/or suggests a simple hypothesis | • Forms an appropriate hypothesis and prediction<br>• Designs an investigation | |
| • Identifies simple materials and equipment to be used | • Identifies materials and equipment to be used<br>• Is able to assemble simple apparatus | • Identifies the materials and equipment to be used<br>• Assembles simple apparatus | • Identifies and names the materials and equipment to be used<br>• Assembles and designs or modifies simple apparatus | |
| • Follows directions as provided | • Follows directions as provided<br>• Is able to write simple procedural statements | • Develops and organizes a simple written procedure | • Designs and writes descriptions of procedures that are clear and detailed | |
| | • Prepares observation charts, tables, and diagrams as directed by teacher | • Prepares observation charts, tables, diagrams, graphs<br>• Performs calculations as outlined by teacher | • Prepares observation charts, diagrams, and graphs<br>• Performs necessary calculations | |

## B. Collecting and Recording

| Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|
| • Follows a simple procedure | • Follows a simple procedure | • Follows a given procedure and is able to suggest modifications when asked to do so | • Follows a given procedure and modifies the procedure when necessary | • Performs at a level beyond level 4 |
| • Correctly uses apparatus and materials as directed by teacher | • Correctly uses apparatus and materials with little teacher assistance | • Correctly uses apparatus and materials with infrequent modification | • Consistently uses standard apparatus and materials correctly | • Characteristic of work done at college or university level |
| • Collects data using concrete, tangible objects | • Collects tangible objects<br>• Carries out simple measurements | • Accurately collects data | • Accurately collects relevant data | |
| • Records data in sentence form or in simple charts that have been constructed | • Records data in numerical and non-numerical form<br>• Is able to use and construct simple charts | • Records relevant data including the correct units with respect to measured data | • Records relevant data using the appropriate units | |
| • Is aware of safety and environmental concerns<br>• Follows stated safety procedures | • Is aware of safety and environmental concerns<br>• Follows stated safety procedures | • Shows appropriate safety and environmental concerns in the use, care, and maintenance of materials and apparatus | • Demonstrates appropriate standards of safety | |
| | | • Is able to locate appropriate safety regulations<br>• Actively participates in teacher-directed discussion of safety and environmental issues | • Is able to suggest modifications to procedures to minimize environmental damage | |

## C. Organizing and Communicating

| Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|
| • Organizes data in sets of concrete objects | • Organizes data in sets of objects | • Organizes data in the form of sets, themes, and/or tables | • Organizes data accurately | • Performs at a level beyond level 4 |
| | • Provides a basis for the organization of data sets<br>• Constructs simple graphs to represent the data | • Provides a basis for and suggests alternatives for the organization of data<br>• Is able to construct graphs and/or tables to represent the data | • Is able to represent data using appropriate graphs and tables | • Characteristic of work done at college or university level |
| | • Performs basic mathematical calculations | • Performs basic mathematical calculations | • Performs relevant and required mathematical calculations | |
| | • Identifies, with teacher assistance, errors and inaccuracies | • Identifies errors and discrepancies in data<br>• Takes part in teacher-directed discussion of scientific inaccuracies | • Expresses measured and calculated quantities to correct degree of precision | |

## D. Analysing

| Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|
| • Correctly identifies patterns within the data | • Assesses patterns and trends that are conceptually presented by the data | • Assesses patterns, trends, and simple relationships | • Assesses patterns, trends, and relationships resulting from collected and manipulated data | • Performs at a level beyond level 4 |
| • Identifies, with teacher assistance, relationships | • Identifies simple cause and effect relationships | • Identifies cause and effect relationships | • Identifies the sources of error in data collection and manipulation | • Characteristic of work done at college or university level |
| | • Identifies, with teacher assistance, the sources of error in data collection and manipulation | • Identifies the sources of error in data collection and manipulation | • Expresses accuracy qualitatively and/or quantitatively (percent difference), where applicable<br>• Identifies the assumptions relating to measurement and/or analysis | |
| | • Identifies, with teacher assistance, the effect of errors on results | • Suggests amendments to procedures and/or data manipulation in order to rectify results | • Determines the reliability of the data | |

## E. Connecting, Synthesizing, and Integrating

| Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|
| • Provides a simple but not necessarily appropriate answer to the problem investigated based on results obtained | • Provides a simple answer that is appropriate for the problem investigated and results obtained | • Provides an appropriate answer to the problem investigated based on results obtained | • Provides a qualified answer to the problem investigated | • Performs at a level beyond level 4 |
| | • Attempts to relate results to knowledge that is not specifically related to scientific theories or laws | • Relates results, with teacher assistance, to applicable theories and/or laws | • Relates the data to laws, principles, models, or theories identified in background information and/or in broader context | • Characteristic of work done at college or university level |
| | | | • Proposes and explains interpretations or conclusions<br>• Develops theoretical explanations | |

## F. Evaluating Progress or Outcomes

| Level 1 | Level 2 | Level 3 | Level 4 | Level 5 |
|---|---|---|---|---|
| • Attempts to explain results to the problem investigated | • Attempts to explain results to the problem investigated | • Is able to explain the results obtained in light of the problem being investigated | • Evaluates the prediction and concepts | • Restricts, revises, or replaces an unacceptable scientific concept |
| | • Attempts to draw conclusions where applicable and when prompted | • Draws conclusions and attempts to explain them | • Draws conclusions and attempts to explain them | • Establishes criteria to judge the design, prediction, and concepts |
| | | • Discusses the limitations of the data collected, interpretations, and/or conclusions | • Identifies limitations of the data and information, interpretations, or conclusions, as a result of the design of the experiment, research, or project | • Considers consequences and perspectives<br>• Evaluates assumptions and effects of bias |
| | | • Discusses, when prompted, the validity of results<br>• Discusses, when prompted, alternatives and/or improvements to the experimental design | • Suggests alternatives and considers improvements to experimental technique and design | • Evaluates the total investigation in terms of reliability and validity |

## Science Skills Spreadsheet

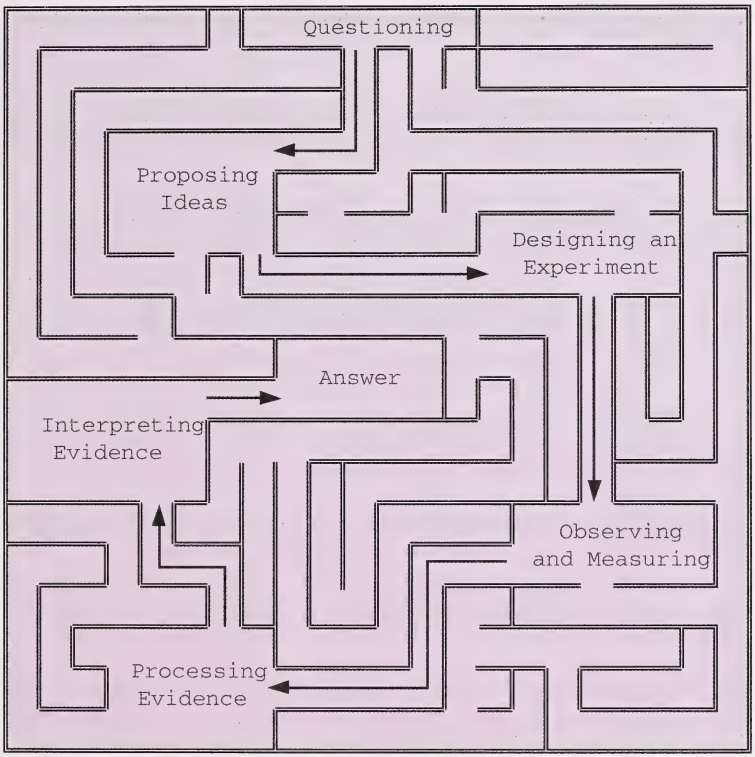
You may reproduce this spreadsheet as required for use in this course.

| SKILL ASSESSMENT RECORD | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feedback from Assignments | | | Initiating and Planning | | Collecting and Recording | | Organizing and Communicating | | Analysing | | Synthesizing and Integrating | | Evaluating | |
| Module | Section | Question | Self | Teacher | Self | Teacher | Self | Teacher | Self | Teacher | Self | Teacher | Self | Teacher |
| 1 | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | |

# Suggested Answers

## Section 1: Activity 1

1.




2. The sequence generally follows a pattern such as questioning, proposing ideas, designing an experiment, observing and measuring, processing evidence, and interpreting evidence.

3. In drawing the diagram you are collecting information about size, shape, names of the parts, and so on. In tracing the blood flow and labelling, you are also collecting information.

4. In tracing the flow of the blood and in answering questions 1 to 6 from the Analysis and Interpretation section of *Visions 3*, you are analysing how the various parts work.

5. In answering question 7 from the analysis and interpretation, you are performing the science skill of synthesizing since you are making predictions.

6. In answering Textbook question 8 you would have to devise a plan to carry out the research. Although you are not required to write out the plan, you have to do some planning in order to do the research.

7. The level at which you rate yourself will depend on how well you feel you performed the required task. For example, if you drew an accurate, well-labelled diagram, you might give yourself a 3 or a 4 for the skill of collecting. If your diagram was not well drawn or if you did not label it accurately, you would rate your skill level for collecting at a 1 or a 2. If you feel you did a good job of answering questions 1 to 8, you would give yourself a 3 or a 4 for the skills of analysing, synthesizing, and initiating. You may have rated your skill level at a 3 or 4 in one skill and at a 1 or a 2 in another skill.

## Section 1: Activity 2

1. A circulatory system is required in multicellular organisms because materials have to be transported over longer distances than in unicellular organisms and therefore cannot rely on diffusion alone. Diffusion is a transport process that works well over a short distance.

2. It would take about 0.5 seconds to diffuse across a cell, whereas it would take about eight months to diffuse from the lungs to your calf muscle. This shows that diffusion works well over short distances but not over long distances.

3. The heart functions as two pumps. The right side of the heart pumps blood from the heart to the lungs and back to the heart. This is called pulmonary circulation. The left side of your heart pumps blood from the heart to the rest of the body, except the lungs, and back to the heart. This is called systemic circulation.

4. **Textbook step 1:** Your drawing should reflect the photographic guide of the pig heart. Remember, you are doing a ventral view. For help with tracing the blood flow, see Plate 1.1 on page P-1 of *Visions 3*.

5. **Textbook step 2:** The superior vena cava (20) and inferior vena cava empty into the right atrium (13). In comparison to the ventricles (15, 16), the atria are smaller and the walls are much thinner.

6. **Textbook step 3:** In comparison to the atria (13, 14), the ventricles (15, 16) are larger and have thicker walls. The walls of the right ventricle (15) are thinner than the walls of the left ventricle (16).

7. **Textbook step 4:** The tricuspid valve (24) is composed of three flaps or cusps of tissue and separate the right atrium (13) from the right ventricle (15). The valves are supported by elastic type tissue called chordae tendinae (26) that are anchored to the ventricle wall. Note: To help you remember the location of the tricuspid valve, the "ri" in tricuspid can be used as a reminder for the right side.

8. **Textbook step 5:** Note that the vessels emerging from the ventricle come out at the top of the heart. There are no vessels that come out of the bottom of the heart.

9. **Textbook step 6:** Note that the mitral valve is also called the bicuspid valve (23). It is called the mitral valve because it has a similar shape to the bishop's hat or mitre. Find the parts you are to label on your drawing on the photographic chart.

10. **Textbook question 1:** The walls of the atria are much thinner than those of the ventricles. The atria are responsible for collecting blood and pumping it into the ventricles. Because the atria do not have to pump a very long distance, the walls do not have to be that thick. In contrast, the walls of the ventricles are much thicker because they must pump blood out at a higher pressure than the atria. The left ventricle must create the greatest pressure, requiring more muscle tissue. The right ventricle must create much more pressure than the atria. It is not as muscular as the left ventricle but is more muscular than the atria.

**Textbook question 2:** The three cusps or flaps of the tricuspid valve are easily pushed aside by blood flowing from the right atrium to the right ventricle. When the ventricle contracts, it pushes blood into the cup-shaped side of the cusps and fills them. This pushes the edges of the valve together, thus stopping the backward flow of blood into the atria.

**Textbook question 3:** The mitral or bicuspid valve withstands the greatest pressure. This valve has fibrous material (called chordae tendineae) attached to the cusps, which support them when they are experiencing pressure and prevent the cusps from opening backwards to allow blood flow into the atrium.

**Textbook question 4:** The prefix *bi* means two. The mitral has two cusps and therefore is called bicuspid. The tricuspid has three cusps, thus the prefix *tri*.

**Textbook question 5:** The right atrium and ventricle contain deoxygenated blood. The chambers of the left side of the heart contain oxygenated blood. Pulmonary arteries carry deoxygenated blood. The aorta and all other systemic arteries carry oxygenated blood.

**Textbook question 6(a):** An adult heart beats, on the average

$(72 \text{ beats/min})(60 \text{ min/h}) = 4.32 \times 10^3$ (4 320) beats/h

$\left(4.32 \times 10^3 \text{ beats/h}\right)(24 \text{ h/d}) = 1.03 \times 10^5$ (103 000) beats/d

$\left(1.03 \times 10^5 \text{ beats/d}\right)(7 \text{ d/wk}) = 7.26 \times 10^5$ (726 000) beats/wk

$\left(7.26 \times 10^5 \text{ beats/wk}\right)(52 \text{ wk/a}) = 3.77 \times 10^7$ (37 700 000) beats/a

**Textbook question 6(b):** The heart of a resting adult would pump, on the average, 300 L every hour, $7.2 \times 10^3$ L (7 200 L) a day, $5.04 \times 10^4$ L (50 400 L) a week, and $2.62 \times 10^6$ L (2 620 800 L) a year.

**Textbook question 6(c):** The heart of a resting adult would, on the average, do $4 \times 10^3$ J (4 000 J) of work in an hour, $1 \times 10^5$ J (100 000 J) of work in a day, $7 \times 10^5$ J (700 000 J) of work in a week, and $3 \times 10^7$ J (30 000 000 J) of work in a year.

**Textbook question 7:** Any damage to the bicuspid (mitral) valve would allow blood to flow backward into the atrium when the left ventricle contracts. As a consequence, not enough blood would be pumped through the systemic circulation. When more oxygen was needed in the tissues, chemoreceptors would signal the brain, which would signal the heart to beat more rapidly and forcefully. As the force created by the left ventricle became greater, it would exert more pressure on the valve, possibly causing more damage.

**Textbook question 8:** One of the conditions that could be researched would be rheumatic fever, which is caused by a streptococcal infection. The bacteria releases a toxin that, through a series of events, causes scar tissue to form on the valves, sealing them together in places. As well, certain bacteria can infect the valves and prevent them from closing properly. For example, endocarditis can be fatal.

## Section 1: Activity 3

1.

| Blood Vessel Type | Structure with regards to the thickness of the walls | Function |
|---|---|---|
| Arteries | Compared to capillaries and veins, arteries have the thickest walls due to a thick, smooth muscle layer. | Arteries carry blood away from the heart to all parts of the body. |
| Capillaries | Capillaries have the thinnest walls compared to arteries and veins. The walls are one cell thick. The reason for the thin walls is so nutrients and gases can pass through the wall. | Capillaries are responsible for the exchange of gases, nutrients, and wastes. |
| Veins | Veins have walls that are usually thinner than arteries. This is because the veins have a thinner smooth muscle layer than arteries. Compared to capillaries, the walls of veins are thicker. Walls of veins do not have to be as thick as those of the arteries since the blood pressure is lower in veins than in arteries. | The function of the veins is to carry blood towards the heart. |

2. No, not all arteries carry oxygenated blood. The exceptions are the pulmonary arteries which carry deoxygenated blood to the lungs from the heart. No, not all veins carry deoxygenated blood. The exceptions are the pulmonary veins which carry oxygenated blood to the heart from the lungs. Remember the following:

   - All arteries carry blood away from the heart, but not all arteries carry oxygenated blood.
   - All veins carry blood to the heart, but not all veins carry deoxygenated blood.

3. Small arteries are known as **arterioles**, while small veins are known as **venules**.

4. The walls of arteries are more elastic than veins. The increased elasticity found in arteries is required to absorb much of the force of the pulse by expanding with each contraction. The recoiling action in arteries, which occurs between heartbeats, forces blood onwards.

5. **Textbook question 4:** One-way valves are required to ensure one-way flow towards the heart. This is necessary because the pressure in veins is much lower than that found in arteries. Since arteries have a higher pressure in them, one-way valves are not required to maintain one-way flow.

6. Capillaries serve as excellent areas for exchange because of the following:

   - Their walls are only one cell thick which allows for diffusion of nutrients and wastes.
   - They make up a large cross sectional surface area (larger than that of arteries).
   - Blood velocity is the lowest in capillaries.

7.

| | Observations |
|---|---|
| **Relative Wall Thickness** | The walls of the capillary should be the thinnest compared to walls of other vessels in the fish tail. |
| **Relative Diameter** | The diameter of the capillaries should be the smallest of all the vessels in the tail. |
| **Relative Velocity** | The velocity of blood moving through the capillaries should be the slowest of all the vessels in the tail. |

8. The walls of capillaries are the thinnest of the vessels to allow for easy exchange between the blood and the cells. If the walls were thick, they would be less permeable.

The diameter (lumen) of the capillaries are the smallest of the vessels to allow for limited passage through. This enhances the exchange process. If the diameter was larger, more material would pass through in a shorter period of time and exchange would not be as efficient.

The velocity through the capillaries is the slowest of the vessels which enhances exchange. If blood moved through faster, exchange would not be as efficient.

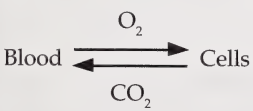
9.

| | Observations |
|---|---|
| **Stroked towards the hand** | The blue colour disappears in the region where the pressure was applied and does not reappear until the pressure is removed. |
| **Stroked towards the elbow** | The blue colour returns almost immediately as it is stroked. |

0. When a vein is stroked towards the hand, the blue colour disappears in a region of the vein. This is because blood that was in that particular region has been pushed further along and maintained there due to the one-way valves, and at the point where the index finger finishes, blood flow has been blocked. Both of these events result in the disappearance of the vein. When the pressure is removed, the vein reappears since blood flow is unblocked and the valves have "blue" blood to push towards the heart.

When the vein is stroked towards the elbow the colour reappears immediately since the stroking action is in the same direction as the blood flow and therefore the blood flow is not blocked. This allows the valves to continue to work and maintain blood flow towards the heart.

1. Diffusion is a passive type of transport (no energy has to be added to the system) that moves molecules from an area of higher concentration to an area of lower concentration.

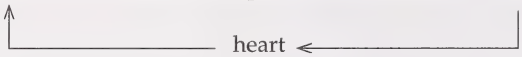
2. 

13. Bulk flow enhances the diffusion process between a capillary bed and the surrounding tissue. Bulk flow is the net movement of fluid due to the opposing forces of blood pressure (tends to move fluid out of the capillaries) and osmotic pressure (tends to move fluid into the capillaries due to a higher protein concentration in the blood). One difference between diffusion and bulk flow is that diffusion is efficient over short distances, whereas bulk flow is better over longer distances.

14. The role of the lymphatic system is to remove excess fluid and proteins from between cells and return them to the blood.

15. The function of the valves in the lymphatic system is to prevent the backflow of fluid (similar function to valves in veins).

16. arteries → arterioles → capillaries → venules → veins




17. The best defence against circulatory problems is a healthy lifestyle which includes regular exercise, low cholesterol diet, and not smoking.

18. The function of the coronary arteries, which branch off the aorta, are to supply the heart muscle with oxygen and nutrients.

19. Atherosclerosis is a condition that results in a buildup of plaque (thickening) in one or more arteries resulting in reduced blood flow and an increase in blood pressure.

20. If atherosclerosis is not treated, it may result in a heart attack (death of heart muscle) or a stroke (lack of oxygen reaching the brain).

21. Atherosclerosis may be treated by angioplasty which involves squishing the plaque to increase the diameter in the artery to restore proper blood flow. If the condition is more serious and involves the coronary arteries, a coronary bypass may be performed which involves taking part of a vein and attaching it to the aorta and placing the other end beyond the constriction to bypass the damaged area.

22. There are some risk factors for heart disease that cannot be changed – age, family history, and sex. However, there are lifestyle factors which could effectively reduce your risk of dying of heart disease. These factors could include reducing stress, adjusting your diet to reduce fat and cholesterol intake, not smoking, maintaining normal weight, and increasing your activity level.

## Section 1: Activity 4

1. Blood consists of cells and plasma.

2. A major type of cell found in blood is the red blood cell (RBC) or erythrocyte.

3. Examples of two noncellular materials found in the blood include glucose and oxygen.

4. Plasma refers to the liquid portion of the blood. It may have dissolved materials in it such as glucose and/or oxygen.

5. Plasma is mainly composed of the following:

| | |
|---|---|
| Water | 90% |
| Proteins | 7% |
| Nutrients, wastes, gases, hormones | 2% |
| Salts (ions of sodium, potassium, calcium, magnesium, chlorine, and carbonate) | 1% |

6. Some possible functions for plasma are transporting nutrients and oxygen to the cells and wastes and carbon dioxide from the cells. The plasma also serves to transport hormones to the various parts of the body.

7. **Textbook question 1:** On the average, red blood cells are 7.5 μm in diameter and 1.9 um thick at their thickest point. You may have to review the steps used to calculate diameters as given on page 470 of *Visions 3*.

**Textbook question 2:** There should be no visible structures inside the red blood cells since they have no nucleus.

**Textbook question 3:** Red blood cells have a large surface area for diffusion to occur. Due to their disk shape, oxygen does not have to travel far to reach the surface. White blood cells are large and have the ability to engulf foreign particles.

**Textbook question 4:** White blood cells are significantly larger than red blood cells.

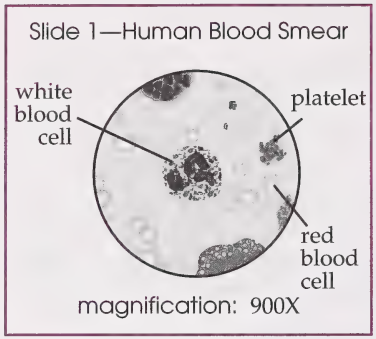
**Textbook question 5:** The nuclei of white blood cells are large and of varying shapes with some nuclei taking up half the cell. Some nuclei are round, while others are crescent shaped.

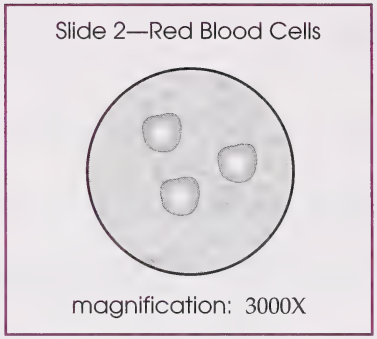
**Textbook question 6:** There about 700 red blood cells for every white blood cell. Every cell in the body requires oxygen; therefore, a large number of red blood cells are required to carry the required oxygen. White blood cells fight infections which may be only in one area. The white blood cells can gather at the site from various parts of the body.

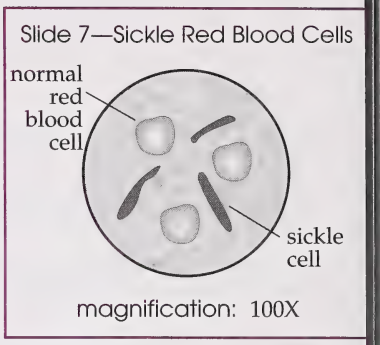
**Textbook question 7:** All red blood cells look alike. You may be able to see several shapes of white blood cells. The white blood cell contents may look something like that shown in Slide 1 in the answer to question 8 in Part B.

**Textbook question 8:** You may be able to see some fragments of cells which are called platelets. Platelets have no nucleus and range in size from 2 to 4 μm in diameter.

8.




9. Red blood cells are in the highest proportion in the blood (5 million in one drop of blood). There are approximately 700 red blood cells to 1 white blood cell.

10. a. The major function of RBCs is to transport oxygen to the cells.

    b. With respect to WBCs, there are several types of them, but they all play a defensive role in fighting infection and disease.

    c. Platelets are cell fragments that are involved in the blood-clotting process.

11. The biconcave shape increases the surface area for oxygen transport.

12. One structural difference is that red blood cells are generally smaller than white blood cells. Another structural difference is that red blood cells do not contain a nucleus, whereas white blood cells do.

13. The absence of a nucleus in red blood cells allows them to transport more oxygen to the cells. Another consequence of not having a nucleus is that red blood cells are incapable of reproducing inside the blood stream. Red blood cells have a lifespan of about 120 days.

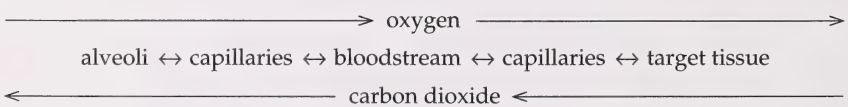
14. Oxygen enters the body through the process of breathing (external respiration). You inhale oxygen from the atmosphere.

15. The organelle responsible for energy production in the cell is the mitochondrion.

16. Carbon dioxide is produced through the process of cellular respiration. It is removed from the body through the breathing process, by exhaling it out.

17. Gas exchange occurs in the tiny air sacs of the lungs called the alveoli.

18. At the site of the lungs, oxygen diffuses from the lung tissues into the bloodstream, whereas at the site of the target tissues, oxygen diffuses from the bloodstream into the cell-containing tissues. Carbon dioxide transport is also through diffusion but the direction of movement is opposite that of oxygen. See the flow chart that follows



19. **Textbook question 1:**

| | Oxygen Transport | Carbon Dioxide Transport |
|---|---|---|
| hemoglobin | 97% | 23% |
| dissolved in plasma | 3% | 7% |
| hydrogen carbonate ions* | – | 70% |

* also known as bicarbonate ions

20. Digestion is the process of breaking down large molecules so that they may be transported across the membranes of the intestinal walls and into the blood stream.

21. Most of the digestion process takes place in the small intestine.

22. The nutrients move from the digestive tract to the bloodstream in the small intestine.

23. The two key processes involved in the absorption of nutrients into the bloodstream are diffusion and active transport.

24. The purpose of the villi is to increase the surface area to enhance the absorption of nutrients into the blood stream.

25. The lymphatic vessels absorb about 80 to 90% of the fat.

26. The liver is involved with the processing of nutrients once they get into the bloodstream. This processing may involve storage, conversion to another chemical form, synthesis of new materials, or removal of toxic substances.

27. The liver is responsible for carrying out the following functions:

    - It is the site where glucose is converted to its storage form, glycogen. It is also where glycogen is converted back into glucose if the body requires it. Remember glucose is a reactant in cellular respiration which is responsible for energy production.
    - It is the site where fat-soluble vitamins are stored.
    - It is the site where the nitrogenous waste product urea is formed.
    - It is the site where proteins found in the blood plasma are synthesized.
    - It is the site where chemicals are broken down to allow easier removal by the kidneys.
    - It is the site of bile production; bile is a chemical substance required for the physical breakdown of fats in the digestive system.

28. Excessive alcohol consumption causes liver cells to die and be replaced by scar tissue resulting in the restriction of blood flow. This prevents the liver from performing many of its critical functions.

29. The processing units of the kidney are microscopic structures known as nephrons.

30. Blood flows into each nephron through a ball of capillaries known as the **glomerulus**.

31. The first part of the nephron that receives materials from the glomerulus is called **Bowman's** capsule.

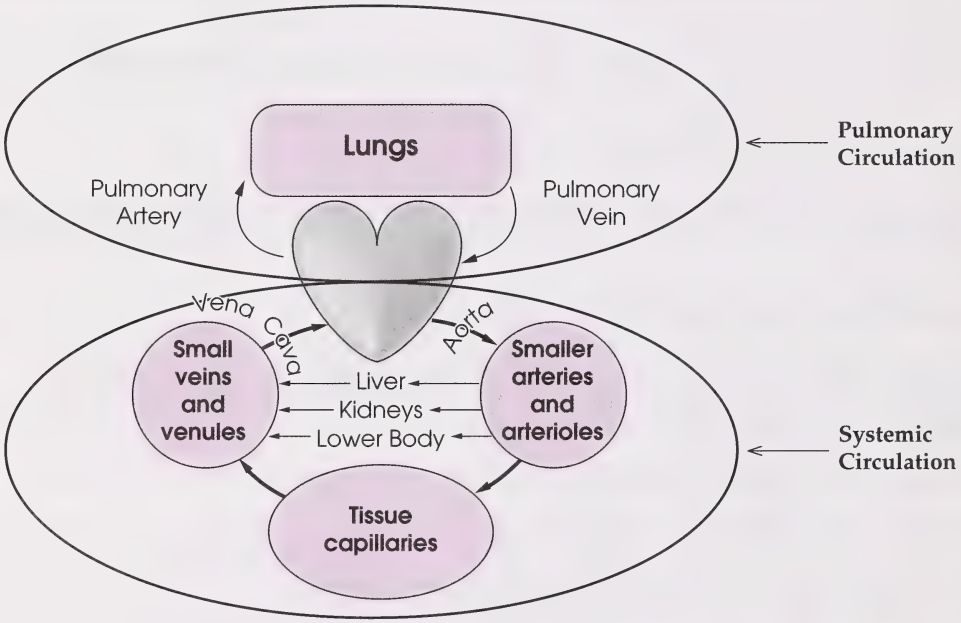
32. Two substances that may be reabsorbed back into the bloodstream are glucose and amino acids. These substances will only be reabsorbed if there are insufficient quantities in the blood.

33. The waste products leaving the collecting tubules of the nephron will form **urine**.

34. Blood entering the right side of the heart is low in oxygen and high in carbon dioxide. This blood comes from the body cells. The right ventricle pumps this blood to the lungs. Blood entering the left side is oxygen rich as it is coming from the lungs. This blood will be pumped to the body cells by the left ventricle, leaving the heart through the main aorta.

35. The circulatory system supplies blood to the lungs where gas exchange takes place. Oxygen diffuses into the capillaries of the microscopic alveoli and carbon dioxide diffuses out. This exchange ensures that blood leaving the lungs and going back to the heart is rich in oxygen. The respiratory and circulatory systems are partners in supplying the body cells with oxygen and in removing carbon dioxide and water. The two systems also regulate body temperature by conserving or dissipating body heat.

36.




## Section 1: Activity 5

1. This statement means that blood flow varies throughout the body. When a particular system or structure is active, it will have increased blood flow to it. After eating a large meal, blood flow to the digestive system will be increased and less blood will be sent to the skeletal muscles (involved with movement of body parts). This is why you should not go out and exert yourself right after eating. It is important to note that the volume of blood stays relatively the same.

2. Nervous and hormonal mechanisms are involved with maintaining proper cardiac output and blood pressure.

3.

baroreceptors in carotid artery and aorta stretch

↓

stimulates a nerve impulse to be sent to the part of the brain known as the medulla

↓

nerve impulses sent back to the heart and blood vessels

↓

causes heartbeat and cardiac output to decrease to normal resting values and causes arteries and veins to dilate (increase in diameter)

↓

blood pressure returns to normal resting values

4. The kidneys play a role in maintaining proper blood pressure. Angiotensin II causes the following:

- Blood vessels decrease in diameter (or constrict) which increases blood pressure.
- The retention of water and salt in the blood increases the blood volume therefore contributing to an increase in pressure.

5. The following are sample results observed by Alberta students. Your results will vary.

| Activity | Systolic Pressure (mm/Hg) | Diastolic Pressure (mm/Hg) | Blood Pressure (systolic/diastolic) | Pulse Rate (beats/min) |
|---|---|---|---|---|
| Sitting | 120 | 80 | $\frac{120}{80}$ | 73 |
| Standing | 121 | 82 | $\frac{121}{82}$ | 75 |
| Lying | 118 | 78 | $\frac{118}{78}$ | 71 |
| *Running (taken immediately) | 140 | 92 | $\frac{140}{92}$ | 141 |
| *Three minutes after running | 125 | 84 | $\frac{122}{74}$ | 78 |

* Note: These results will depend on whether one is jogging, sprinting, and so on.

6. Pulse should be lowest while lying down. Even when sitting or standing, muscles are used to support posture. When lying down, muscles are in their most relaxed state and the heart is not doing any work against gravity.

7. Exercise should increase both pulse rate and blood pressure. As the muscles use oxygen and produce carbon dioxide, the reduced oxygen level and increased carbon dioxide level in the blood will be detected by chemoreceptors (receptors which detect chemicals in the blood). Signals will be sent to stimulate the heart. The increase in the strength of contractions will cause an increase in blood pressure and an increase in heartrate.

8. The pulse rate and blood pressure readings taken three minutes after running should have been lower than those taken immediately after running.

9. Individuals who are more physically fit should exhibit a smaller change in pulse rate and blood pressure and a quicker return to normal conditions after exercise. Trained athletes usually have developed muscles that are more vascular and thus have a greater supply of oxygen. Developed muscles may also have more mitochondria and thus provide more energy for the muscle. This would mean that the circulatory system would not have to work as hard to satisfy requirements for intake of oxygen and removal of carbon dioxide.

10. Your chart of pulse rate may be similar to the following.

| Activity | Sitting | Standing | Lying | Running (taken immediately) | Running (taken three minutes after running) |
|---|---|---|---|---|---|
| Pulse rate | 73 | 75 | 71 | 141 | 78 |

11. See the answers to question 6 and to questions 7 to 9 as they pertain to pulse rate only.

12. The blood pressure reads 120/80. The systolic pressure is 120 mm Hg and the diastolic pressure is 80 mm Hg.

13. Three effects of high blood pressure include the following:

    - High blood pressure may cause injury to the arteries, which may lead to a heart attack or stroke (affects the brain). In the case of a heart attack, the coronary arteries are damaged.
    - High blood pressure may damage kidney tissue, which may lead to kidney failure.
    - High blood pressure may overwork the heart muscle, which may lead to heart failure.

14. Health professionals agree that blood pressure should be considered high when systolic pressure is consistently over 140 mm Hg or diastolic pressure is over 90 mm Hg. If your blood pressure reading was consistently higher than normal, you may have hypertension. One high reading could be the result of anxiety or some cause other than hypertension.

15. As you get older, the chances of you getting high blood pressure increase. This is because arteries lose their elasticity as you get older. Your arteries may also become constricted as fatty deposits build up on the inside walls. Both of these factors will increase blood pressure levels.

16. Two possible symptoms associated with high blood pressure could be headaches and nosebleeds.

## Follow-up Activities

### Extra Help

1. a. superior vena cava
   b. pulmonary artery
   c. right atrium
   d. bicuspid valve (mitral valve)
   e. tricuspid valve
   f. inferior vena cava
   g. aorta
   h. left atrium
   i. pulmonary veins
   j. semilunar valve (aortic)
   k. left ventricle
   l. septum
   m. right ventricle

2. a. 1 superior and inferior venae cavae — deoxygenated
   b. 4 pulmonary artery — deoxygenated
   c. 2 right atrium — deoxygenated
   d. 8 aorta — oxygenated
   e. 6 left atrium — oxygenated
   f. 5 pulmonary veins — oxygenated
   g. 7 left ventricle — oxygenated
   h. 3 right ventricle — deoxygenated

3. a. vein
   b. capillary
   c. artery
   d. artery
   e. vein
   f. capillary
   g. artery
   h. artery

4. a. red blood cell (erythrocyte) – main function is to transport oxygen to the cells of the body
   b. white blood cell (leukocyte) – main function is to fight infection and disease
   c. platelet – cell fragment that aids in blood clotting

   Red blood cells occur in the largest quantity compared to the other blood components. There are about 700 RBC for every 1 WBC.

5. When you are involved in strenuous exercise, your **breathing** rate increases to bring more oxygen into your body and your **heart** rate increases to send more oxygen to your cells by way of the bloodstream. The circulatory system is kept under control by two mechanisms. With respect to the **nervous** mechanism, specialized nerve endings called **baroreceptors** initiate nerve impulses that are sent to the **medulla** of the brain. This part of the brain will interpret the situation and determine whether to increase or decrease the activity of the heart along with blood pressure. With respect to **hormonal** control, the two hormones involved are **adrenaline**, which causes the strength and rate of the heartbeat to increase, and **angiotensin II**, which causes an increase in blood pressure.

## Enrichment

1. To aid in the dissection of the heart, refer to the Extra Help, question 1 in the Module Booklet. The value of the dissection is to give you a three-dimensional perspective of what the heart really looks like inside and out. Students are usually quite amazed by the difference between the atria and the ventricles. You should be able to notice that the left ventricle is thicker than the right ventricle. You should also be able to distinguish between an artery and a vein based on the wall thickness.

2. **Think question 1:** When the heart contracts, the arteries and arterioles that reach deep into the heart muscle to feed the muscle itself are compressed. During systole, blood flow to the heart muscle is reduced about 2.5 times compared with diastole. If the diastolic pressure remains high, the heart muscle never relaxes enough to permit the proper flow of blood to the heart muscle itself.

   **Think question 2:** When blood pressure is low, the osmotic pressure drawing blood into the capillaries will be higher than the average blood pressure pushing fluid out. Therefore, bulk flow will be reduced. Fluid will tend to be drawn out of the tissues into the capillaries. The major consequence is that the exchange process is less efficient.

   **Think question 3:** In 1.0 mL of whole blood there is approximately 0.14 g of hemoglobin $(0.34 \times 0.40)$. The volume of oxygen that can be carried by 1.0 mL of whole blood is about 0.19 mL $(0.14\,\text{g} \times 1.39\,\text{mL/g})$.

   **Think question 4:** Blushing occurs when arterioles in the skin of the face open up and allow large amounts of blood to flow near to the surface.

   **Think question 5:** The presence of folds and villi in the small intestine increase the surface area to allow for more efficient absorption of nutrients into the blood stream. The surface area of the small intestine is $600\,\text{m}^2$, about the size of a baseball diamond.

   **Think question 6:** The large amount of active transport occurring in the kidneys uses a large amount of energy.

   **Think question 7:** If there are problems with the kidney, this could result in more volume of fluid staying in the blood, which would cause an increase in blood pressure.

3. Hemophiliacs require specific factors, Factor 8 or 9, to enable their blood to clot. This factor is isolated from whole blood received by Red Cross blood donors. Approximately 100 units of Factor 8 are isolated from 1 unit of donated blood (450 mL). A 60 kg person with hemophilia requires approximately 1500 units of Factor 8 for one treatment. Considering that injections generally consist of three treatments per week, approximately 45 donated units are required for that one person per week.

4. If you do visit a blood donor clinic, it is a great opportunity to ask any questions that you have concerning blood. It should be noted that you may visit the clinic without having to donate blood.

5. The laserdisc contains an abundance of valuable information that would help improve your understanding of the concepts studied in this section.

6. The purpose of the video is for you to improve your understanding of homeostasis and the transport processes that occur in your body.

## Section 2: Activity 1

1. a. sensors—heat sensor, pain sensor, pressure sensor, or cold sensor

   b. cells—fat cells

   c. nerves—sensory nerves

   d. glands—sweat glands, sebaceous oil glands

2. Three ways the skin is able to protect your body from infection include the following:

   - acts as a barrier to prevent penetration of viruses and bacteria
   - secretes acidic substances which maintain a skin pH between 3 and 5 creating conditions that would kill many microorganisms
   - secretes substances such as tears, saliva, and perspiration that contain the enzyme lysozyme that breaks down bacterial cell walls and kills the organisms

3. Foreign organisms that are breathed in are filtered by nasal hair or trapped in the sticky mucus. The mucus is secreted by mucous membranes which line the inside of the respiratory tract. Once in the mucus, cilia, also lining the tract, beat upwards moving the mucus and foreign organisms towards the throat. At the throat, the mucus is coughed out or is swallowed. If it is swallowed, the bacteria or virus will be killed by the stomach acid in the digestive tract. Bacteria or viruses swallowed with food are also killed by stomach acid. It should be noted that mucous membranes are mainly found in the respiratory and digestive tracts.

4. Macrophages and neutrophils are white blood cells capable of a process known as phagocytosis. Phagocytosis is a type of active transport which involves the swallowing of solid particles by cells. It should be noted that the difference between macrophages and neutrophils is that macrophages are a longer lasting phagocytic cell. Neutrophils will self-destruct after undergoing phagocytosis.

5. A fever kills harmful bacteria and prevents them from spreading throughout the body. This is because the higher temperature associated with fever makes it difficult for bacteria to survive. It should be noted that it is not safe to allow a child to have too high of a fever since it may cause convulsions or damage cells.

6. All blood cells are produced in the bone marrow, the inside cavity of the bone. All blood cells originate from stem cells, which are unspecialized cells that give rise to specialized cells such as blood cells.

7. The inflammatory response would indicate tissue injury either through invasion of a foreign microorganism or if a scratch or cut had occurred.

8. Three effects of histamine include the following:

    - dilation of blood vessels in the region of the damaged area to increase blood flow
    - greater leakage out of capillaries to allow attack of foreign organisms in the tissues
    - migration of phagocytic cells to the damaged site

## Section 2: Activity 2

1. It would be important for the immune system to distinguish between foreign cells and its own so that it would not destroy its own cells. Having this characteristic allows for maximal protection for the body.

2. The specific defence mechanisms can be distinguished from the nonspecific defence mechanisms since the specific defence mechanism

    - is able to recognize specific foreign agents
    - is able to distinguish between self cells and foreign cells
    - has a memory of foreign invaders.

3. Antigens are foreign substances that invade your body and cause an immune response. The antibody is one of the products of the immune system formed in reaction to the antigen. Therefore, the antigen is not produced by the body and causes an immune response, whereas the antibody is produced by the body and is part of the immune response.

4. The immune system is able to distinguish surface proteins found on its own cells from surface proteins found on foreign invaders.

5. T lymphocytes are responsible for cellular immunity and are produced in the bone marrow like all blood cells.

6. No, not all T cells are the same. Each T lymphocyte synthesizes a unique protein receptor which it carries on its surface.

7. The three requirements for a proper fit include the following:

    - "self" complex fit which means that the two cells have identified each other as being "self"
    - foreign antigen must fit the specialized receptor protein on the surface of the T lymphocyte
    - release of the protein messenger cytokine to stimulate the T lymphocyte

8. State the function of the following types of T lymphocytes.

    a. helper T cells—help other T lymphocytes carry out their function

    b. killer (or cytotoxic) T cells—with the aid of helper T cells attack and destroy any infected cell containing the specific antigen

    c. suppressor T cells—turn off the immune response once the infectious agent has been completely destroyed

    d. memory T cells—specific helper T cells and killer T cells which remain in the immune system prepared t respond to the same antigen if it enters the body in the future

9. Killer T cells recognize transplanted organs as being foreign agents and attack them. Drugs must be administered to suppress the action of these killer T cells so that the transplanted organ will not be rejected.

10. The AIDS virus is believed to attack helper T cells. The significance of this is that the virus attacks the very cells which are responsible for protecting the body against disease. This explains why AIDS victims die of rare disorders. Since their immune systems are not functioning properly, they suffer more harmful effects.

11. B lymphocytes are involved with humoral immunity and these cells are also produced in the bone marrow.

12. Activation of B lymphocytes results in the formation of a clone of plasma cells that synthesize specific protein antibodies.

13. Once the antigen-antibody complex is formed, it may either be engulfed by phagocytic cells or it may be killed by proteins in the blood.

14. The three possible effects include the following:

    - drop in blood pressure resulting in insufficient oxygen transport
    - constriction of the bronchioles of the lungs making breathing more difficult
    - triggering of asthma attacks

15. Autoimmune disease is when the immune system does not recognize certain cells or substances as "self" and begins to attack them.

16.

| | | |
|---|---|---|
| a. humoral | e. T | h. helper |
| b. lymphocytes | f. memory | i. killer (or cytotoxic) |
| c. cellular | g. suppressor | j. antibodies |
| d. B | | |

17. Jenner inoculated some cowpox abscess (pus) into a child and found that it provided some degree of protection against smallpox.

18. Pasteur discovered that living organisms cause disease. His second major finding was that bacteria and viruses could be weakened and used to inoculate people and immunize them against disease without causing major harm.

19. Vaccinations are possible for polio, tetanus, cholera, influenza (various strains), smallpox, diptheria, plus a number of other diseases.

20. The value of vaccinations is that they allow for the development of immune protection, specifically the production of antibodies and T cells, without suffering the harmful effects of the disease. Vaccinations have also reduced the death rate due to contagious diseases.

21. The helper T cells identify the organism.

22. The system is so effective because the various cells—macrophages, helper T cells, killer T cells—all work together to destroy the invader.

23. The memory T cells keep a blueprint of the invading organism so that next time it will be recognized and the immune system can start fighting the infection immediately.

24. The helper T cells are destroyed by the AIDS virus.

25. There is no specific disease caused by the AIDS virus. The AIDS virus works by destroying part of the immune system so that the body cannot fight other common diseases such as pneumonia, influenza, cancer, and so on.

26. Immunization involves a similar virus or weak virus being injected into the body. The immune system creates memory T cells so that when the real virus comes in, the immune system is ready to destroy it.

## Section 2: Follow-up Activities

### Extra Help

1. The first line of defence is primarily a physical barrier that is represented by the skin and the mucous membranes. The skin offers an impermeable barrier to intruding pathogens. The mucus secreted by the lining of the respiratory system continually traps pathogens and the cilia move them up and out of your body. (Coughing effectively sends them far from your body.) In addition, your stomach offers chemical protection as the acidic content effectively destroys most microbes (viruses and bacteria).

2. a. iii b. i c. ii d. iv

### Enrichment

1. **Textbook question 8:** The skin feels warm around an infection because of the increased activity to combat the infection.

   **Textbook question 9:** You feel chilly because your internal thermostat has been reset to a higher temperature. Your body has not reached the set temperature yet and therefore you feel chilly. For example, if your body thermostat is set at 40°C but your body temperature is 38°C (normal body temperature), you will feel cold.

   **Textbook question 10:** The loss of helper T cells would probably create the most serious problems for your immune system because these cells are involved in both humoral and cellular immunity. Without these cells, the entire immune response would be virtually eliminated. This is what happens with AIDS victims. They die of various disorders which are harmful in these individuals because of their weak immune system.

2. **Textbook question 5:** If you have blood type A, this means you have antigen A and anti B antibodies in your system. If type AB blood was transfused into your system, it would not be compatible because your anti B antibodies would attach to the B antigen from the AB blood and cause clumping or agglutination. This could lead to blood clot formation.

3. EMTs provide a valuable service to society and have saved thousands of lives over the years. It makes for an exciting and rewarding career. Answers as to why you may find a career as a paramedic rewarding will vary.

4. The videodisc provides excellent images of antibodies, lysis, agglutination, and phagocytosis. The section on blood types explains the ABO blood system, illustrates how blood type is determined, and shows the results of mixing different types of blood.

5. a. An individual's blood type is identified by the antigen carried on their red blood cells (RBCs); for example, people with blood type A have antigen A on their RBCs and antibody B in their plasma. The blood on Slide 5 agglutinated (clotted) with blood plasma from type A blood which contains antibody B. The incoming antigen must have matched antibody B for it to clot; therefore, it was from type B blood. This is confirmed as there was no clotting in type B plasma.

   b. Upon contact with torn blood vessels the platelets congregate to seal the cut site. The injured tissue releases a protein called thromboplastin. The thromboplastin combines with blood calcium to cause prothrombin (a plasma protein) to become thrombin. Thrombin breaks apart the huge fibrinogen molecule to form fibrin fibres. The fibrin creates a blood clot which appears red as the RBCs are trapped inside it.

## Section 3: Activity 1

1. • What is the basic structure of membranes?
   All membranes are composed of lipids (includes compounds commonly referred to as fats and oils), protein, and carbohydrates. The organization of these compounds is such that there is a lipid bilayer (two layers) with proteins found beside it and embedded in it. Carbohydrates are located on the outside of the membrane. One of the key functions of the proteins is to allow for transportation through the membrane.

   • What is the most important function of the nucleus?
   The most important function of the nucleus is that it is the brain of the cells. It controls all the functions of the cell including reproduction.

   • What is active transport?
   Active transport allows the movement of materials from an area of low concentration to an area of high concentration (or against the concentration gradient). This process involves a protein in the membrane and requires energy input.

   • How does a cell obtain energy for processes such as active transport?
   Any energy-requiring process obtains its energy through the process of cellular respiration which takes place in the mitochondria of the cell.

   • What is an ion?
   An ion is an atom with a charge associated with it due to excess protons (+) or electrons (–).

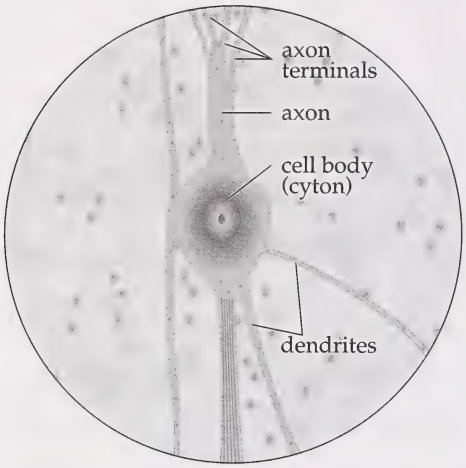
   • What is electric current?
   Electric current refers to the flow of electrical charge (created by the presence and motion of electrons, protons, and other charged particles).

   • What is voltage or an electrical potential difference?
   Voltage is a form of potential energy that occurs when positive and negative charges are separated. In living cells, a small separation of ions by the cell membrane creates an electrical potential cell.

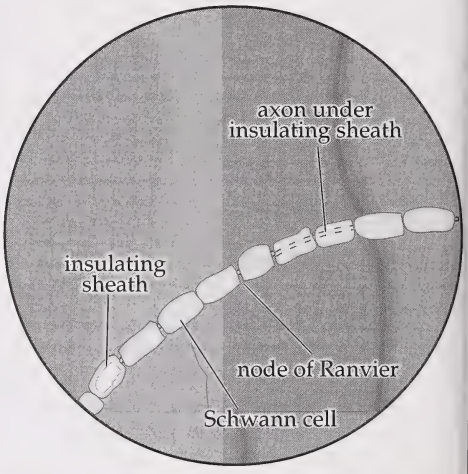
   • What is an electrical conductor?
   An electrical conductor is a structure that allows for the passage of electrical current through it. An example would be electrical wire.

   • What is an electrical insulator?
   An electrical insulator is any material that reduces or prevents the conduction of an electrical current. An example would be the covering around electrical wire.

2. The drawing should be similar to the following one.




3. The drawing should be similar to the following one.



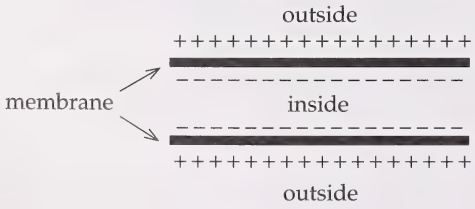

4.

| Structure | Function |
|---|---|
| Dendrite | conveys impulses toward the cell body |
| Axon | carries impulses away from the cell body toward target cells or next neuron |
| Myelin Sheath | consists of many layers of membrane derived from Schwann cells |
| Node of Ranvier | points where the axon membrane is in contact with the extracellular fluid (fluid found outside the nerve cell) |

5. **Textbook question 3:** A myelin sheath would make a good electrical insulator. The Schwann cell membranes (i.e., myelin sheath) are composed of lipid material and this is an excellent insulator material.

6. The sodium-potassium pump is an active transport system. It uses energy from ATP to transport three sodium ions out of the cell while moving two potassium ions into the cell. Note that the cell in this case is the neuron.

7. The charge outside the membrane is positive while the charge on the inside is negative. This difference in charge across the membrane sets up a voltage or electrical potential difference.



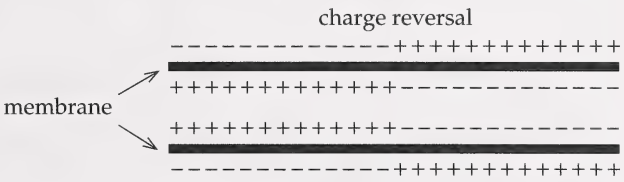

Note that the electrical potential difference occurs across the membrane as opposed to different ends of the neuron.

8. The neuron is unique in that its membrane can undergo sudden, large changes in permeability to sodium and potassium ions.

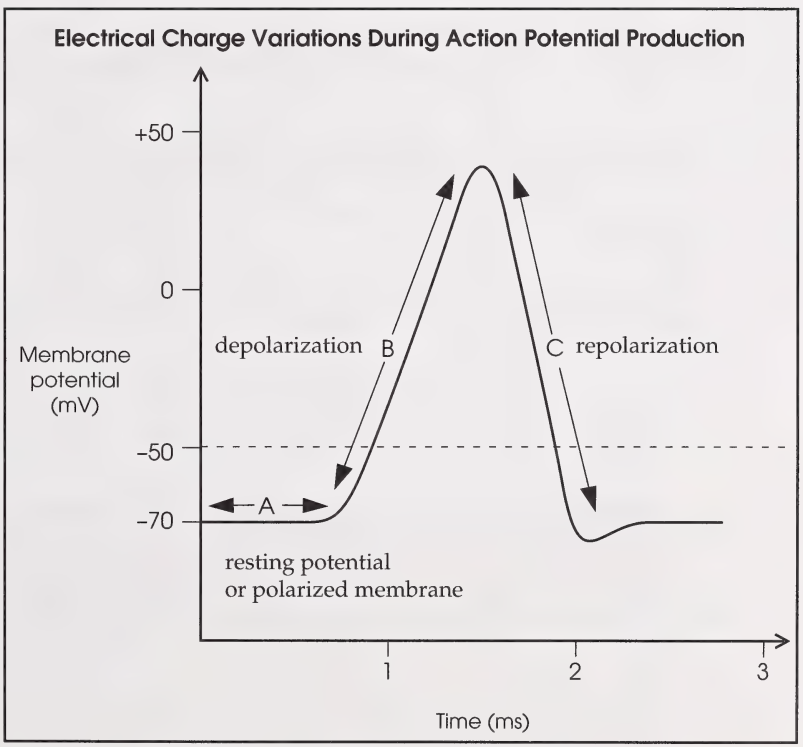
9. An action potential refers to the series of events that create a nerve impulse.

10. Threshold refers to the voltage required for an action potential to be created. This voltage change is due to the movement of sodium ions into the neuron when it is stimulated. Because sodium ions are positive in charge, the inside of the neuron becomes negative (about – 50 mV). If this threshold value is not obtained, there is no action potential and therefore no nerve impulse. Different neurons may have different thresholds to stimulate them to produce an action potential.

11. Once threshold has been obtained, sodium ions continue to move into the cell. In fact so much sodium moves in that the inside of the neuron becomes positive in charge and the outside becomes negative. The inside of the membrane reaches a charge of about +30 mV. Refer to the graph in Figure 2.4 on page 42 of your text.




12. Your graph should be labelled as shown at the right. The answers to the question for what occurs at each section is given as follows.




Section A—At this stage sodium ($Na^+$) and potassium ($K^+$) ions are diffusing unequally across the membrane. At the same time, $Na^+/K^+$ pumps more $Na^+$ ions out of the neuron. The result is an excess of positive charge on the outside. The membrane is said to be polarized.

Section B—The membrane at this point becomes more permeable to $Na^+$ ions and a sudden influx of $Na^+$ ions into the cell occurs. The result is a reverse in the charge. The positive charge is now on the inside of the cell. This state is called depolarization.

Section C—The membrane now stops the flow of $Na^+$ ions and becomes permeable to $K^+$ ions which move outward rapidly. This reverses the charge again and returns the membrane to its original potential. This state is called repolarization.

13. The nodes of Ranvier are regions in the axon that are not insulated by the myelin sheath. The nodes are where action potentials may take place. The significance of this is that rather than the nerve impulse travelling through the entire axon, it actually "jumps" from one node to another. This results in a much faster nerve impulse transmission.

14. The nerve impulse is referred to as an all-or-none event because each impulse is the same. Once threshold has been reached, the nerve impulse will fire with the same strength each time. The aspect of all or none is in reference to the idea that the impulse either fires completely or not at all. It does not fire at different strengths.

15. A synapse is a junction between two neurons and includes the synaptic cleft or space between the neurons, as well as the ends of each of the neurons.

16. Neurotransmitters are chemicals released from the presynaptic neuron and travel across to the postsynaptic neuron. The neurotransmitter acts as a messenger passing on information to the postsynaptic neuron.

17. **Synaptic** vesicles fuse with the axon membrane and release a **neurotransmitter** into the synaptic cleft (part of a synapse). The neurotransmitter **diffuses** across the **synapse** and binds to special **receptor** molecules in the **postsynaptic** membrane.

18. Once the neurotransmitter binds to the postsynaptic membrane, it will either cause stimulation or inhibition of the neuron.

19.

| | Stimulatory Response | Inhibitory Response |
|---|---|---|
| Type of ion moving ($Na^+$ or $K^+$) | sodium | potassium |
| Direction of ion movement (in or out of the postsynaptic neuron) | sodium moves into cell | potassium moves out of cell |
| Resulting change in charge (depolarization or hyperpolarization) | inside of postsynaptic neuron becomes more positive (depolarizes) | inside of postsynaptic neuron becomes more negative (hyperpolarizes) |
| Nerve impulse stimulated or inhibited | impulse in postsynaptic neuron stimulated | impulse in postsynaptic neuron inhibited |

20. Once neurotransmitters have completed their function, they are either broken down or actively transported back to the presynaptic membrane.

21. Acetylcholine is an example of a neurotransmitter. Cholinesterase (also know as acetylcholinesterase) is an enzyme. Cholinesterase is responsible for breaking down acetylcholine once it has completed its function.

22. a. Curare is a poison that binds to acetylcholine and prevents it from attaching to the postsynaptic membrane. This results in a lack of information getting to the postsynaptic membrane and therefore causes paralysis. Paralysis is the inability for the body's muscles to respond appropriately.

    b. Organophosphate insecticides bind to cholinesterase and therefore prevent the breakdown of acetylcholine. This results in continual stimulation of the postsynaptic membrane leading to overstimulation of muscles and glands. This leads to convulsions and even death. Note that the effects of curare and insecticides are different. With curare there is a lack of stimulation of the postsynaptic membrane, whereas with organophosphate insecticides there is an overstimulation.

    c. Amphetamines resemble neurotransmitters and can add to the effect of the neurotransmitter. The overstimulation can lead to a state of euphoria. Note that the overstimulation is not to the same degree as with insecticides.

23. a. Alzheimer's disease is caused by a loss of neurons in a specific locations of the brain. With this loss of neurons there is less acetylcholine released. This results in a deterioration of memory. This progressive disease can eventually deteriorate the memory to the point where the individual is unable to talk, think, or carry out simple tasks.

    b. Parkinson's disease is due to the reduction in the number of neurons that produce the neurotransmitter dopamine. This disease causes muscle tremors, rigidity of arms and legs, and a generalized reduction in motion.

## Section 3: Activity 2

1. The drawing should be similar to Figure 2.7 on page 47 of your text.

2.

| Structure | Function |
|---|---|
| pupil | is the opening through which light enters the eye |
| iris | is the muscle that controls the size of the pupil |
| lens | bends light rays so that they fall and form a focused image on the retina |
| retina | contains the light-sensitive receptors called rods and cones when stimulated receptors will create a nerve impulse |
| optic nerve | transmits the nerve impulse to the brain so that it may be interpreted |

3.

| | To See Distant Objects | To See Nearby Objects |
|---|---|---|
| Ciliary Muscles (relax/contract) | relax | contract |
| Tension of Suspensory Ligaments (increased/decreased) | increased | decreased |
| Shape of Lens (flattens/bulges) | flattens | bulges |

4. The two types of light receptors are rods and cones. The general function of these receptors is to initiate nerve impulses when stimulated.

5. Vitamin A is important for proper vision. Vitamin A comes from carotene, a pigment found in carrots. It is also found in various fruits, vegetables, liver, and dairy products.

6. Rods are more sensitive to light than cones. Rods provide black and white vision. Cones provide sharper images than rods and are used to distinguish colour.

7. With light in the room, you should have been able to see clearly and in colour. As the room got darker, your vision became less clear and less colour was visible. When it was completely dark you could not see anything for a few moments. However, afterwards your eyes adjusted and you were able to see better. Everything in the dark should have appeared black and white. This situation can be interpreted as the cones mainly working in the light, which explains your ability to see clearly and in colour. As it got darker, the rods took over because they were more sensitive to the light. At a particular point of darkness, the cones became nonfunctional. Since only the rods were functioning in the dark, this would explain why images appear in black and white and they were not as clear.

8. The fovea is the area on the retina that contains the greatest concentration of cones. This area provides the sharpest vision.

9. a. The blind spot is located where the optic nerve leaves the eye.

   b. It is called the blind spot because when light hits this area of the retina, there is no visible image. This is because there are no rod or cone receptors in this region to create a nerve impulse. With no nerve impulse, there is no image.

   c. When you move the book closer the X reappears. This is because light from the X is no longer focusing on the optic nerve but is focusing on the active part of the retina.

10. Colour blindness occurs when the cone cells fail to respond properly. There are varying degrees of colour blindness. There are some individuals who cannot see any colour, while others cannot see certain colours. Refer to Plate 2.4 on page P-5 of *Visions 3* to see a common test used to determine colour blindness. Colour blindness is usually an inherited condition.

11. The three structures involved with balance are the utricle, saccule, and the semicircular canals.

12. The utricle, saccule, and semicircular canals contain specialized hair cells which response to head movements.

13. The tendency of the fluid is to stay stationary or in the direction it is moving (its inertia), while the cilia which are attached to the body move in the changing direction of the merry-go-round. This causes the fluid to push against the cilia. This push against the cilia is sent as a nerve impulse and interpreted by the brain as motion. As the direction keeps changing, the fluid pushes in a different direction. This change in direction is interpreted by the brain from its three semicircular canals which interpret motion in different planes.

14. The hair cells (ciliated cells), when stimulated appropriately, will create nerve impulses which are sent to the brain for interpretation.

15. Motion sickness is due to overstimulation of the receptors, specifically those found in the semicircular canals. Fluid is moving in all directions which sends the brain a whole series of mixed messages.

16. Mechanoreceptors are located in the skin and also in tendons, muscles, and joints. Mechanoreceptors respond to stretching or pressure. They are actually modified dendrites of a neuron.

17. Pain receptors provide a warning to the brain to remove the body from a damaging stimulus. Although you would be more comfortable in the absence of pain, your body would soon receive damage and you would lose many functions.

## Section 3: Activity 3

1. The two major divisions of the human nervous system are the central nervous system and the peripheral nervous system.

2. The two main parts of the central nervous system are the brain and spinal cord.

3. The peripheral nervous system is composed of sensory and motor neurons.

4. The four systems making up the peripheral nervous system are the somatic nervous system, the autonomic nervous system, and the two divisions of the autonomic nervous system—the sympathetic nervous system and the parasympathetic nervous system.

5. The central nervous system receives and processes information coming in from the senses and directs responses to stimuli. It is the "thinking" part of the nervous system.

6. The peripheral nervous system serves as the link between the central nervous system and the rest of the body.

7. Your drawing should reflect the photograph in the Precise Photographic Guide. From the photograph note that the longitudinal fissure divides the right and left hemispheres of the brain.

8. Your drawing should reflect the photograph in the Precise Photographic Guide. Check to be sure that you have labelled the required parts accurately.

9.

| Structure | Function |
|---|---|
| cerebrum | • conducts higher-level mental activities such as learning and memory<br>• controls voluntary actions |
| cerebellum | • is the centre for muscle coordination and balance |
| medulla oblongata | • controls involuntary actions such as breathing, heart rate, sneezing, and coughing |
| corpus callosum | • allows for communication between the two hemispheres |
| hypothalamus | • regulates body temperature and influences heart rate and respiration<br>• associated with pain, anger, sex drives, hunger, thirst, pleasure<br>• regulates many endocrine (hormonal) functions |

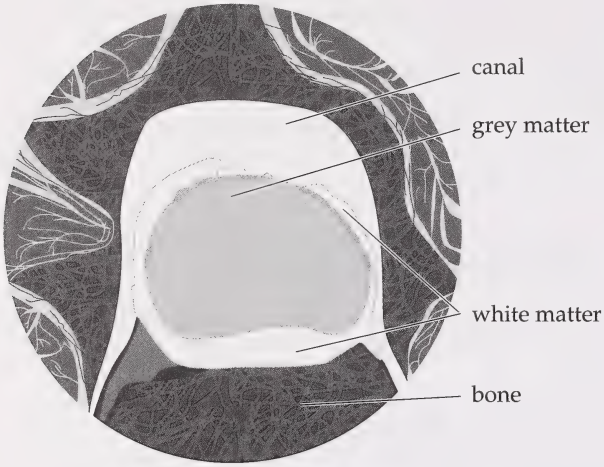
10. The cerebrum of the brain has undergone the greatest evolutionary changes and is what sets the human species apart from all other species. The large size of the cerebrum has allowed the human species to have a great capacity for intelligence.

11. The left hemisphere controls the right side of the body and the right hemisphere controls the left side of the body.

12. The sensory neuron carries information from the receptors to the central nervous system. If this neuron was cut, the central nervous system would not receive the information, and therefore there would be no sensation.

13. The motor neuron carries information from the central nervous system to the effector. If this neuron was cut, the effector would not receive information and therefore would not carry out the response.

14. Your drawing should be similar to the following.




15. The grey matter of the spinal chord is largely made up of cell bodies of neurons.

16. There are about 12 billion neurons in the grey matter of the brain.

17. The estimated number of connections is $10^{23}$ or one followed by twenty-three zeros.

18. A large number of connections are necessary so the brain can analyse the vast amount of information that reaches it every second.

19. The central nervous system processes and interprets data, whereas the peripheral nervous system does not do any processing or interpretation. The PNS only sends and receives information. The function of the PNS is to simply act as messengers or couriers.

20. The cell bodies of most sensory neurons are found outside the spinal column (backbone) in clusters called ganglia. The cell bodies of motor neurons are found within the skull and spinal column. Remember that the cell body of a neuron contains the nucleus, the control centre for the cell.

21.

| | Autonomic Nervous System | Somatic Nervous System |
|---|---|---|
| Does it control skeletal muscles or smooth muscles and glands? | smooth muscles, glands, and cardiac muscle (Note that smooth muscles make up your internal organs.) | skeletal muscles |
| Is it under voluntary or involuntary control? | involuntary control (e.g., You cannot make your digestive tract muscles contract.) | voluntary control (e.g., You can voluntarily make your bicep muscles contract.) |
| Is it under conscious or unconscious control? | unconscious control (Your body is doing it without you knowing about it.) | conscious control (Your body is doing it with you knowing about it.) |

22. The sympathetic nervous system prepares your body for a response to fear, stress, or emergencies. This is called the fight or flight response.

23. The sympathetic nervous system is responsible for causing any of the following:

- dilation of the pupils
- weak stimulation of saliva
- relaxation of bronchi (respiratory tubes in the lungs)
- acceleration of heartbeat and strengthening of contraction
- inhibition of digestive system activity
- stimulation of glucose release (makes more energy available)
- secretion of adrenaline and nonadrenaline
- relaxation of bladder
- stimulation of ejaculation of sperm cells

## Section 3: Activity 4

1. 
- receptor – produces a nerve impulse when stimulated by something in the environment (light, smell, touch)
- sensory neuron – carries nerve impulse from receptor to spinal cord
- spinal cord – processes and interprets nerve impulse
- interneuron – links sensory with motor neuron
- motor neuron – sends information from spinal cord to effector
- effector (muscle or gland) – carries out response (muscle contraction or hormone release from a gland)

2. The brain is not involved in the reflex arc. This would allow for a faster response since the information does not have to travel to the brain for processing. The processing and interpretation is done by the spinal cord.

3. Pupillary Reflex – The correct order is Step 3, Step 4, Step 1, and Step 2.

Reaction Rate – The correct order is Step 1, Step 7, Step 5, Step 6, Step 3, Step 2, and Step 4.
The table for your results mentioned in Step 4 could be like the one shown in the answer to the reaction rate in question 4.

4. For the pupillary reflex, you should have observed that the pupil in the closed eye was larger than the pupil in the opened eye. For the reaction rate, the answers may vary but should be similar to the following.

| Trial | Left Hand | Right Hand |
|---|---|---|
| 1 | 12 | 12 |
| 2 | 16 | 13 |
| 3 | 13 | 12 |
| 4 | 15 | 11 |
| 5 | 12 | 15 |
| Average | 14 | 13 |

You should have had faster times for your dominant hand which in the preceding case was the right hand. You may have also improved your rates as you had more practice. To calculate averages you add up the measurements for each hand and divide by the number of trials.

5. The manipulated variable for the pupillary reflex was the amount of light received by the eye. The closed eye received no light while the opened eye did.

6. The responding variable for the pupillary reflex was the size of the pupil. The responding variable for the reaction rate was the distance the ruler fell before being caught.

7. Any two of the following variables are acceptable:

   - same ruler used for all trials
   - thumb and index finger kept 4 cm apart
   - ruler dropped within fifteen seconds
   - same person releasing ruler each time
   - ruler placed just above thumb and index finger for each trial
   - same table used to rest arm on
   - all trials done at one time

8. A reflex is not learned behaviour; it is instinctive. Its neural pathway follows the reflex arc. Therefore, there is no processing or interpretation by the brain. A response is a learned behaviour. The neural pathway is receptor, sensory neuron, spinal cord, brain, spinal cord, motor neuron, and effector. The brain rather than the spinal cord does the interpretation of information. Also, response time can be improved upon with practice. A reflex will react the same way all the time.

9. The pupillary reflex would be considered a true reflex while the reaction rate experiment involves a response. The pupillary reflex is not a learned behaviour, it is instinctive. Also the pupil will react the same way each time. The reaction rate is a learned response. It can be improved on with practice.

10. The major difficulty in reconnecting severed nerves is that it is not enough to just reconnect the nerve endings. It is the individual axons within the nerve that must be reconnected. These are too small to be successfully reconnected at the present time.

11. Lou Gehrig's disease disintegrates the nerve cells causing the loss of use of the muscles. Death usually occurs when the respiratory muscles fail.

12. The muscles of his respiratory system as well as the heart muscle must still be functioning.

13. **Textbook question 3:** Answers will vary. Such a diagnosis would mean that as muscle use diminishes over the next few years, you would have to learn to do more things which involved just using the brain. If you have been very physically active up to this point, the effect may be greater than if your hobbies up to now include reading or using a computer.

14. In addition to the immediate satisfaction of helping people use their limbs again, you will have the satisfaction of helping people gain confidence and make the most of their lives.

15. The nervous system takes in sensory information, integrates it into memory, and determines the appropriate responses. It allows you to participate in the world around you.

16. There are two basic divisions: the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS is composed of the brain and spinal cord and it is housed in protective bone. The PSN is composed of all the nerves, twelve pairs of cranial and thirty-one pairs of spinal nerves. It also includes the autonomic nervous system (ANS) which regulates the activity of the internal organs.

17. Sharon's brain uses visual data from her eyes, tactile information from her skin, and olfactory scents to trigger her memory so she can identify the objects. Finally, her taste buds give her chemical information that confirms the object is a peach.

18.

| Sensory Receptor | Cerebral Cortex Lobe |
|---|---|
| olfactory cells | temporal |
| rods and cones | occipital |
| hair cells in ear | temporal |
| higher intellectual activities | frontal |

19. Jim's brain is better than a computer because it not only integrates sensory information and stores it, but it allows Jim to formulate and create ideas.

20. The ANS maintains homestatic control of the circulatory, respiratory, and digestive systems. The cerebellum integrates proprioceptive (pressure, position) information from the muscular and skeletal systems to achieve involuntary coordination.

## Section 3: Follow-up Activities

### Extra Help

1. a. dendrites
   b. cell body (or cytoplasm of cell body)
   c. nucleus
   d. axon
   e. myelin sheath
   f. node of Ranvier
   g. axon terminal

2. ___i___ an extension of cytoplasm that carries nerve impulses away from the cell body

   ___k___ the fatty covering over the axon that acts as an insulator

   ___g___ series of events forming a nerve impulse

   ___h___ minimal stimulation to create an action potential

   ___a___ ions that move into the neuron to create a nerve impulse

   ___d___ chemical substances that diffuse across to the postsynaptic membrane

   ___e___ gap between neurons or between neurons and effector

   ___j___ structure of the neuron that receives information

3. Specialized cells that are stimulated by changes in the environment and initiate nerve impulses are called **receptors**.

4. | | | |
   |---|---|---|
   | 12 (lens) | a. | responsible for focusing the image |
   | 8 (iris) | b. | controls the opening and closing of the pupil |
   | 3 (retina) | c. | layer that contains the rods and cones |
   | 5 (optic nerve) | d. | carries impulses from the eye |
   | 4 (fovea) | e. | part of the retina that gives the sharpest images |

5. **Rod** cells are more sensitive to light than **cone** cells.

6. a. The structures responsible for providing information on balance are located in the inner ear.

   b. These structures are the utricle, saccule, and semicircular canals.

   c. The specific receptor cells are hair cells.

7. Touch receptors are located in the **skin** and are called **mechanoreceptors** because they respond to stretching or to **pressure**.

8. a. CNS b. PSN c. PNS d. CNS e. PNS f. PNS

9. The somatic, autonomic, parasympathetic, and sympathetic nervous systems all contain both **motor** and **sensory** neurons.

10. a. F b. T c. T d. F e. T f. F

11. The **sympathetic** nervous system is responsible for responses to emergencies and stress.

12. The pathway represents a reflex arc.

## Enrichment

1. Cerebral palsy is a condition that results from brain damage around the time of birth, usually caused by a lack of oxygen. It results in varying degrees of loss of muscle control. It is not an inherited disorder and it is not contagious. The condition does not get worse with age, nor is it medically curable.

2. **Textbook question 1:** Answers will vary with each student. The correct explanation is local anesthetics (causes a loss of sensation in part of the body) prevent the opening of sodium channels. Thus when an impulse reaches the anesthetized region of the neuron, the impulse is interrupted. The message never reaches the brain. General anesthetics typically act by increasing threshold. This effectively decreases synaptic transmission in many parts of the nervous system.

   **Textbook question 4:** When the lens of the eye hardens, it does not change in shape when the ciliary muscles release tension on the lens. Therefore, the lens cannot focus light from nearby objects.

   **Textbook question 5:** For any wavelength of light, a different combination of the three types of cone cells is stimulated. Each combination is interpreted by the brain as a different colour.

   **Textbook question 7:** Your arms want to move outward. As you maintain continuous pressure, sensory neurons adapt to the stimulus. When the pressure is removed, the neurons sense the opposite sensation and attempt to correct it.

   **Textbook question 8:** A computer core is made of individual "bits" or binary digits that are either on or off. The brain is made of neurons. Each individual impulse is the same as any other. Therefore, an impulse could be likened to "on" and a lack of an impulse could be likened as "off." Both the brain and a computer have a complex network of interconnecting pathways. However, the brain has a more complex network in terms of the number of input signals.

# Science
# Data Booklet

**Note:**

- This booklet provides most of the data needed for your work in this course.
- This data booklet is similar to the booklet used when writing the Science 30 diploma examination.
- Familiarize yourself with the layout and the contents of this data booklet so that you will feel comfortable using it.

Distance Learning

Alberta EDUCATION

# TABLE OF CONTENTS


| Description | Page |
|---|---|
| Miscellaneous | 127 |
| Kinematics and Dynamics Formulas | 129 |
| Gravitational and Electrical Fields | 129 |
| Electricity | 130 |
| Waves | 130 |
| Electrochemistry | 131 |
| Thermodynamics | 132 |
| Periodic Chart of the Elements and Ions | 134 |
| Nuclear Chemistry | 136 |
| Organic Chemistry | 137 |
| Solutions | 137 |
| Acids and Bases | 138 |
| Genetics | 140 |
| Scoring Guides | 141 |

# Miscellaneous

## Data and Equations

solar constant $= 1360 \text{ watts/m}^2$

$$\% \text{ efficiency} = \frac{\text{output}}{\text{input}} \times 100$$

$$\% \text{ error} = \frac{\text{experimental value} - \text{theoretical value}}{\text{theoretical value}} \times 100$$

$$\text{magnification} = \frac{\text{power of ocular lens}}{} \times \frac{\text{power of objective lens}}{}$$

speed of light $= c = 3.00 \times 10^8 \text{ m/s}$

1 light year $= 9.47 \times 10^{15} \text{ m}$

1 AU = astronomical unit

1 AU $= 1.50 \times 10^{11} \text{ m}$

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$$

| SOME NON-SI UNITS USED WITH SI | | | |
|---|---|---|---|
| **Quantity** | **Unit Name** | **Symbol** | **Definition** |
| Time | minute<br>hour<br>day<br>year | min<br>h<br>d<br>a | 1 min = 60 s<br>1 h = 3600 s<br>1 d = 86 400 s<br>1 a = 31 557 600 s |
| Area | hectare | ha | 1 ha = 1 $\text{hm}^2$<br>= 10 000 $\text{m}^2$ |
| Volume | litre | L | 1 L = 1000 $\text{cm}^3$ |
| Mass | metric ton or tonne | t | 1 t = 1000 kg<br>= 1 Mg |
| Pressure | standard atmosphere | atm | 1 atm = 101.325 kPa |

| A SYSTEM OF PREFIXES | | | |
|---|---|---|---|
| **Prefix** | **Symbol** | **Factor by Which Base Unit Is Multiplied** | |
| exa | E | 1 000 000 000 000 000 000 | $=10^{18}$ |
| peta | P | 1 000 000 000 000 000 | $=10^{15}$ |
| tera | T | 1 000 000 000 000 | $=10^{12}$ |
| giga | G | 1 000 000 000 | $=10^{9}$ |
| *mega | M | 1 000 000 | $=10^{6}$ |
| *kilo | k | 1 000 | $=10^{3}$ |
| hecto | h | 100 | $=10^{2}$ |
| deca | da | 10 | $=10^{1}$ |
| deci | d | 0.1 | $=10^{-1}$ |
| centi | c | 0.01 | $=10^{-2}$ |
| *milli | m | 0.001 | $=10^{-3}$ |
| *micro | μ | 0.000 001 | $=10^{-6}$ |
| nano | n | 0.000 000 001 | $=10^{-9}$ |
| pico | p | 0.000 000 000 001 | $=10^{-12}$ |
| femto | f | 0.000 000 000 000 001 | $=10^{-15}$ |
| atto | a | 0.000 000 000 000 000 001 | $=10^{-18}$ |

* most commonly used

## Kinematics and Dynamics Formulas

$\vec{v} = \dfrac{\vec{d}}{t}$

$\vec{a} = \dfrac{\vec{v}_f - \vec{v}_i}{t}$

$\vec{F} = m\vec{a}$

$W = Fd$

$P = \dfrac{W}{t}$

$F_c = \dfrac{mv^2}{r}$

$\vec{d} = \vec{v}_i t + \dfrac{1}{2}\vec{a}t^2$

$\vec{d} = \left(\dfrac{\vec{v}_i + \vec{v}_f}{2}\right)t$

$\vec{p} = m\vec{v}$

$\dfrac{\Delta\vec{p}}{\Delta t} = m\Delta\vec{a}$

$m_1\vec{v}_1 + m_2\vec{v}_2 = m_1\vec{v}_1{}' + m_2\vec{v}_2{}'$

$E_p = mgh$

$E_k = \dfrac{1}{2}mv^2$

$\vec{v}$ = velocity (m/s)
$v$ = speed (m/s)
$\vec{d}$ = displacement (m)
$d$ = distance (m)
$t$ = time (s)
$\vec{a}$ = acceleration $\left(\text{m/s}^2\right)$
$\vec{F}$ = force $\left(\text{kg} \bullet \text{m/s}^2 \text{ or N}\right)$
$m$ = mass (kg)
$W$ = work (N • m or J)
$P$ = power (J/s or watts)
$F_c$ = centripetal force (N)
$r$ = radius (m)
$\vec{p}$ = momentum (kg • m/s)
$E_p$ = potential energy (J)
$g$ = acceleration due to gravity $\left(9.81\ \text{m/s}^2\right)$
$h$ = height (m)
$E_k$ = kinetic energy (J)

## Gravitational and Electrical Fields

$F_g = \dfrac{Gm_1m_2}{r^2}$

$\vec{F}_g = m\vec{g}$

$g = \dfrac{Gm_1}{r^2}$

$F_e = \dfrac{kq_1q_2}{r^2}$

$\left|\vec{E}\right| = \dfrac{\vec{F}_e}{q}$

$\left|\vec{E}\right| = \dfrac{kq_1}{r^2}$

$F_g$ = force due to gravity (N)
$m$ = mass (kg)
$G$ = gravitational constant = $6.67 \times 10^{-11}\ \text{N} \bullet \text{m}^2/\text{kg}^2$
$r$ = centre-to-centre distance (m)
$g$ = acceleration due to gravity = 9.81 $\text{m/s}^2$ or 9.81 N/kg
$F_e$ = force due to electrostatic charges (N)
$k$ = Coulomb's law constant = $8.99 \times 10^9\ \text{N} \bullet \text{m}^2/\text{C}^2$
$q$ = amount of electrostatic charge in coulombs (C)
$\left|\vec{E}\right|$ = electric field strength (N/C) or (V/m)

### Related values:

| | |
|---|---|
| Mass of Earth = $5.97 \times 10^{24}$ kg | Mass of sun = $1.99 \times 10^{30}$ kg |
| Radius of Earth = $6.37 \times 10^6$ m | Elementary charge = $1.60 \times 10^{-19}$ C (charge of a proton or electron) |

# Electricity

## Formulas

For resistances connected in series

$R_T = R_1 + R_2 + R_3 + \ldots R_n$

$R$ = resistance in ohms ($\Omega$)

For resistances connected in parallel

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots \frac{1}{R_n}$$

$$P = IV = I^2 R = \frac{V^2}{R}$$

$V = IR$

$E = Pt$

$P$ = power (watts)

$I$ = current in amperes (A)

$V$ = voltage in volts (V)

$E$ = energy (J)

$t$ = time in seconds (s)

Transformers

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{I_s}{I_p}$$

$N$ = number of turns

p = primary

s = secondary

Output Voltage × Primary Turns = Input Voltage × Secondary Turns

Output Current × Secondary Turns = Input Current × Primary Turns

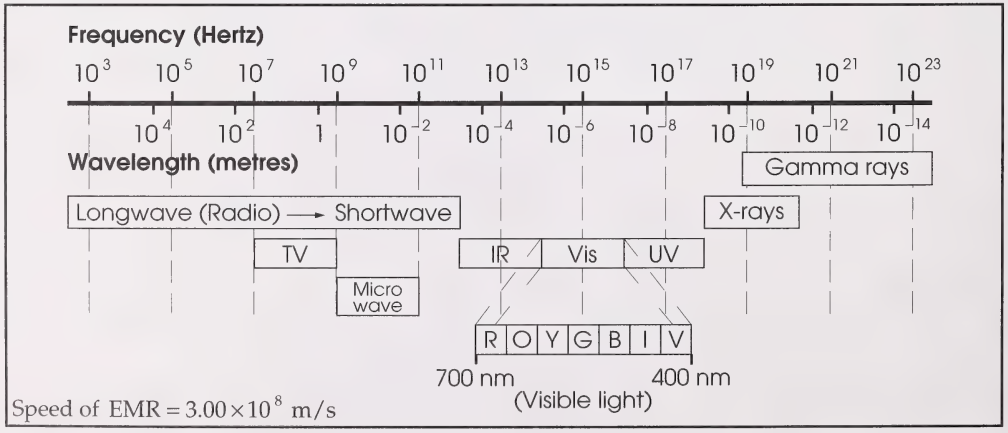
**Related values:** 1 kWh = $3.60 \times 10^6$ J

# Waves

## Wave Formula

$v = f\lambda$ $v$ = speed of wave (m/s) $f$ = frequency (/s or Hz) $\lambda$ = wavelength (m)

**Electromagnetic Spectrum**



# Electrochemistry

**ACTIVITY SERIES (for 1.0 mol/L solution at 25°C)**

**Reduction Half-Reaction**

Metal ions get more stable ↓

| | | | | | |
|---|---|---|---|---|---|
| $Au^{3+}_{(aq)}$ | + | $3e^-$ | → | $Au_{(s)}$ | |
| $Ag^{+}_{(aq)}$ | + | $2e^-$ | → | $Ag_{(s)}$ | |
| $Hg^{2+}_{(aq)}$ | + | $e^-$ | → | $Hg_{(l)}$ | |
| $Cu^{2+}_{(aq)}$ | + | $2e^-$ | → | $Cu_{(s)}$ | |
| $2H^{+}_{(aq)}$ | + | $2e^-$ | → | $H_{2(g)}$ | |
| $Pb^{2+}_{(aq)}$ | + | $2e^-$ | → | $Pb_{(s)}$ | |
| $Sn^{2+}_{(aq)}$ | + | $2e^-$ | → | $Sn_{(s)}$ | |
| $Ni^{2+}_{(aq)}$ | + | $2e^-$ | → | $Ni_{(s)}$ | |
| $Cd^{2+}_{(aq)}$ | + | $2e^-$ | → | $Cd_{(s)}$ | |
| $Fe^{2+}_{(aq)}$ | + | $2e^-$ | → | $Fe_{(s)}$ | |
| $Cr^{2+}_{(aq)}$ | + | $2e^-$ | → | $Cr_{(s)}$ | |
| $Zn^{2+}_{(aq)}$ | + | $2e^-$ | → | $Zn_{(s)}$ | |
| $Al^{3+}_{(aq)}$ | + | $3e^-$ | → | $Al_{(s)}$ | |
| $Mg^{2+}_{(aq)}$ | + | $2e^-$ | → | $Mg_{(s)}$ | |
| $Na^{+}_{(aq)}$ | + | $e^-$ | → | $Na_{(s)}$ | |
| $Ca^{2+}_{(aq)}$ | + | $2e^-$ | → | $Ca_{(s)}$ | |
| $Li^{+}_{(aq)}$ | + | $e^-$ | → | $Li_{(s)}$ | |

↑ Metal atoms get more stable

## Thermodynamics

| HEAT CAPACITIES OF SOME COMMON COMPOUNDS | |
|---|---|
| **Compound** | **Specific Heat Capacity (J/g°C) or kJ/kg°C** |
| Water (liquid) | 4.19 |
| Methanol | 2.55 |
| Ethanol | 2.46 |
| Hexane | 2.26 |
| Water (solid) | 2.01 |
| Water (gas) | 2.01 |
| Toluene | 1.80 |
| Sulphuric acid | 1.13 |

| HEATS OF FUSION OF VARIOUS SUBSTANCES | |
|---|---|
| **Substances** | **Heat of Fusion (J/g) or kJ/kg** |
| Water | 333 |
| Sulphuric acid | 163 |
| Hexane | 152 |
| Ethanol | 109 |
| Methanol | 100 |
| Toluene | 72 |

| HEATS OF VAPORIZATION OF VARIOUS SUBSTANCES | |
|---|---|
| **Substances** | **Heat of Vaporization (J/g) or kJ/kg** |
| Water | 2260 |
| Methanol | 1076 |
| Ethanol | 855 |
| Sulphuric acid | 510 |
| Toluene | 363 |
| Hexane | 335 |

| STANDARD HEATS OF FORMATION AT 298.15 K (25°C) | | |
|---|---|---|
| **Name** | **Formula** | $\Delta H_f^\circ$ **(kJ/mol)** |
| ammonia | $NH_{3(g)}$ | - 46.1 |
| benzene | $C_6H_{6(l)}$ | + 49.0 |
| butane | $C_4H_{10(g)}$ | - 126.5 |
| calcium carbonate | $CaCO_{3(s)}$ | - 1206.9 |
| calcium hydroxide | $Ca(OH)_{2(s)}$ | - 986.1 |
| carbon dioxide | $CO_{2(g)}$ | - 393.5 |
| carbon monoxide | $CO_{(g)}$ | - 110.5 |
| ethane | $C_2H_{6(g)}$ | - 84.7 |
| ethanoic acid (acetic acid) | $CH_3COOH_{(l)}$ | - 484.5 |
| ethanol | $C_2H_5OH_{(l)}$ | - 277.1 |
| ethene (ethylene) | $C_2H_{4(g)}$ | + 52.3 |
| ethyne (acetylene) | $C_2H_{2(g)}$ | + 226.7 |
| glucose | $C_6H_{12}O_{6(s)}$ | - 1273.1 |
| hydrogen sulphide | $H_2S_{(g)}$ | - 20.6 |
| methanal (formaldehyde) | $CH_2O_{(g)}$ | - 115.9 |
| methane | $CH_{4(g)}$ | - 74.8 |
| methanol | $CH_3OH_{(l)}$ | - 239.0 |
| octane | $C_8H_{18(l)}$ | - 250.0 |
| pentane | $C_5H_{12(l)}$ | - 146.4 |
| propane | $C_3H_{8(g)}$ | - 103.8 |
| sucrose | $C_{12}H_{22}O_{11(s)}$ | - 2225.5 |
| sulphur dioxide | $SO_{2(g)}$ | - 296.8 |
| sulphur trioxide (vapour) | $SO_{3(g)}$ | - 395.7 |
| water (liquid) | $H_2O_{(l)}$ | - 285.8 |
| water (vapour) | $H_2O_{(g)}$ | - 241.8 |

$\Delta H_f^o$ for elements is zero

## Energy Formulas

$Q = mc\Delta t$

$\Delta H_{fus} = \dfrac{Q}{m}$

$\Delta H_{vap} = \dfrac{Q}{m}$

$\Delta H = \Sigma \Delta H_f^\circ(\text{products}) - \Sigma \Delta H_f^\circ(\text{reactants})$

$E = \Delta m c^2 \left(c = 3.00 \times 10^8 \text{ m/s}\right)$

$Q$ = quantity of heat energy (kJ)
$m$ = mass (kg)
$c$ = specific heat capacity (kJ/kg°C)
$\Delta t$ = change in temperature (°C)
$\Delta H_{fus}$ = heat of fusion (kJ/kg)
$\Delta H_{vap}$ = heat of vaporization (kJ/kg)
$\Delta H$ = change in heat (kJ)
$\Delta H_f^\circ$ = standard heat of formation (kJ/mol)
$\Sigma$ = the sum of
$\Delta E$ = change in energy (J)

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| IA | IIA | IIIB | IVB | VB | VIB | VIIB | VIIIB | |

| 1 H | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| hydrogen | | | | | | | | |
| 1.01 | | | | | | | | |
| $H^+$ | | | | | | | | |
| hydrogen | | | | | | | | |
| 3 Li | 4 Be | | | | | | | |
| lithium | beryllium | | | | | | | |
| 6.94 | 9.01 | | | | | | | |
| $Li^+$ | $Be^{2+}$ | | | | | | | |
| lithium | beryllium | | | | | | | |
| 11 Na | 12 Mg | | | | | | | |
| sodium | magnesium | | | | | | | |
| 22.99 | 24.31 | | | | | | | |
| $Na^+$ | $Mg^{2+}$ | | | | | | | |
| sodium | magnesium | | | | | | | |
| 19 K | 20 Ca | 21 Sc | 22 Ti | 23 V | 24 Cr | 25 Mn | 26 Fe | 27 Co |
| potassium | calcium | scandium | titanium | vanadium | chromium | manganese | iron | cobalt |
| 39.10 | 40.08 | 44.96 | 47.90 | 50.94 | 52.00 | 54.94 | 55.85 | 58.93 |
| $K^+$ | $Ca^{2+}$ | $Sc^{3+}$ | $Ti^{4+}$ | $V^{5+}$ | $Cr^{3+}$ | $Mn^{2+}$ | $Fe^{3+}$ | $Co^{2+}$ |
| potassium | calcium | scandium | titanium(IV) | vanadium(V) | chromium(III) | manganese(II) | iron(III) | cobalt(II) |
| | | | $Ti^{3+}$ | $V^{4+}$ | $Cr^{2+}$ | $Mn^{4+}$ | $Fe^{2+}$ | $Co^{3+}$ |
| | | | titanium(III) | vanadium(IV) | chromium(II) | manganese(IV) | iron(II) | cobalt(III) |
| 37 Rb | 38 Sr | 39 Y | 40 Zr | 41 Nb | 42 Mo | 43 Tc | 44 Ru | 45 Rh |
| rubidium | strontium | yttrium | zirconium | niobium | molybdenum | technetium | ruthenium | rhodium |
| 85.47 | 87.62 | 88.91 | 91.22 | 92.91 | 95.94 | (98.91) | 101.07 | 102.91 |
| $Rb^+$ | $Sr^{2+}$ | $Y^{3+}$ | $Zr^{4+}$ | $Nb^{5+}$ | $Mo^{6+}$ | $Tc^{7+}$ | $Ru^{3+}$ | $Rh^{3+}$ |
| rubidium | strontium | yttrium | zirconium | niobium(V) | molybdenum | technetium | ruthenium(III) | rhodium |
| | | | | $Nb^{3+}$ | | | $Ru^{4+}$ | |
| | | | | niobium(III) | | | ruthenium(IV) | |
| 55 Cs | 56 Ba | 57–71 | 72 Hf | 73 Ta | 74 W | 75 Re | 76 Os | 77 Ir |
| cesium | barium | | hafnium | tantalum | tungsten | rhenium | osmium | iridium |
| 132.91 | 137.33 | | 178.49 | 180.95 | 183.85 | 186.21 | 190.20 | 192.22 |
| $Cs^+$ | $Ba^{2+}$ | | $Hf^{4+}$ | $Ta^{5+}$ | $W^{6+}$ | $Re^{7+}$ | $Os^{4+}$ | $Ir^{4+}$ |
| cesium | barium | | hafnium | tantalum | tungsten | rhenium | osmium | iridium |
| 87 Fr | 88 Ra | 89–103 | 104 Unq | 105 Unp | 106 Unh | 107 Uns | 108 Uno | 109 Une |
| francium | radium | | unnilquadium | unnilpentium | unnilhexium | unnilseptium | unniloctium | unnilennium |
| (223.02) | (226.03) | | (266.11) | (262.11) | (263.12) | (262.12) | (265) | (266) |
| $Fr^+$ | $Ra^{2+}$ | | | | | | | |
| francium | radium | | | | | | | |

| 57 La | 58 Ce | 59 Pr | 60 Nd | 61 Pm | 62 Sm |
|---|---|---|---|---|---|
| lanthanum | cerium | praseodymium | neodymium | promethium | samarium |
| 138.91 | 140.12 | 140.91 | 144.24 | (144.91) | 150.35 |
| $La^{3+}$ | $Ce^{3+}$ | $Pr^{3+}$ | $Nd^{3+}$ | $Pm^{3+}$ | $Sm^{3+}$ |
| lanthanum | cerium | praseodymium | neodymium | promethium | samarium(III) |
| | | | | | $Sm^{2+}$ |
| | | | | | samarium(II) |
| 89 Ac | 90 Th | 91 Pa | 92 U | 93 Np | 94 Pu |
| actinium | thorium | protactinium | uranium | neptunium | plutonium |
| (277.03) | (232.04) | (231.04) | 238.03 | (237.05) | (244.06) |
| $Ac^{3+}$ | $Th^{4+}$ | $Pa^{5+}$ | $U^{6+}$ | $Np^{5+}$ | $Pu^{4+}$ |
| actinium | thorium | protactinium(V) | uranium(VI) | neptunium | plutonium(IV) |
| | | $Pa^{4+}$ | $U^{4+}$ | | $Pu^{6+}$ |
| | | protactinium(IV) | uranium(IV) | | plutonium(VI) |

## Table of Polyatomic Ions and Elements

**Polyatomic ions**

| | | | |
|---|---|---|---|
| acetate | $CH_3COO^-$ | nitrate | $NO_3^-$ |
| ammonium | $NH_4^+$ | nitrite | $NO_2^-$ |
| benzoate | $C_6H_5COO^-$ | permanganate | $MnO_4^-$ |
| borate | $BO_3^{3-}$ | phosphate | $PO_4^{3-}$ |
| carbonate | $CO_3^{2-}$ | hydrogen phosphate | $HPO_4^{2-}$ |
| hydrogen carbonate | $HCO_3^-$ | dihydrogen phosphate | $H_2PO_4^-$ |
| chlorate | $ClO_3^-$ | silicate | $SiO_3^{2-}$ |
| hypochlorite | $ClO^-$ | sulphate | $SO_4^{2-}$ |
| chromate | $CrO_4^{2-}$ | sulphite | $SO_3^{2-}$ |
| dichromate | $Cr_2O_7^{2-}$ | hydrogen sulphide | $HS^-$ |
| cyanide | $CN^-$ | hydrogen sulphate | $HSO_4^-$ |
| hydroxide | $OH^-$ | hydrogen sulphite | $HSO_3^-$ |

**Elements**

| | |
|---|---|
| astatine | $At_2$ |
| bromine | $Br_2$ |
| chlorine | $Cl_2$ |
| fluorine | $F_2$ |
| hydrogen | $H_2$ |
| iodine | $I_2$ |
| nitrogen | $N_2$ |
| oxygen | $O_2$ |
| phosphorus | $P_4$ |
| sulphur | $S_8$ |

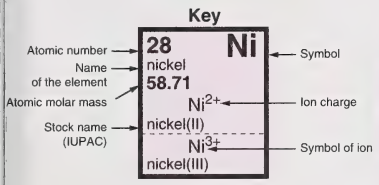
# Elements and Ions

| 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|
| VIIIB | IB | IIB | IIIA | IVA | VA | VIA | VIIA | VIIIA or O |

**Note:**
The legend at the right denotes the physical state of the elements at 101.325 kPa and 298.15 K (25°C).

**Legend for the elements**

| Solid | Liquid | Gas |
|---|---|---|
| Seldom forms ions | | |




Based on $^{12}_{6}C$
Most stable or common ion is listed above dotted line
( ) Indicates mass of the most stable isotope

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1 H<br>hydrogen<br>1.01<br>H⁻<br>hydride | 2 He<br>helium<br>4.00<br>He<br>helium |
| | | | 5 B<br>boron<br>10.81<br>B<br>boron | 6 C<br>carbon<br>12.01<br>C<br>carbon | 7 N<br>nitrogen<br>14.01<br>N3-<br>nitride | 8 O<br>oxygen<br>16.00<br>O2-<br>oxide | 9 F<br>fluorine<br>19.00<br>F⁻<br>fluoride | 10 Ne<br>neon<br>20.17<br>Ne<br>neon |
| | | | 13 Al<br>aluminum<br>26.98<br>Al3+<br>aluminum | 14 Si<br>silicon<br>28.09<br>Si<br>silicon | 15 P<br>phosphorus<br>30.97<br>P3-<br>phosphide | 16 S<br>sulphur<br>32.06<br>S2-<br>sulphide | 17 Cl<br>chlorine<br>35.45<br>Cl⁻<br>chloride | 18 Ar<br>argon<br>39.95<br>Ar<br>argon |
| 28 Ni<br>nickel<br>58.71<br>Ni2+<br>nickel(II)<br>Ni3+<br>nickel(III) | 29 Cu<br>copper<br>63.55<br>Cu2+<br>copper(II)<br>Cu+<br>copper(I) | 30 Zn<br>zinc<br>65.38<br>Zn2+<br>zinc | 31 Ga<br>gallium<br>69.72<br>Ga3+<br>gallium | 32 Ge<br>germanium<br>72.59<br>Ge4+<br>germanium | 33 As<br>arsenic<br>74.92<br>As3-<br>arsenide | 34 Se<br>selenium<br>78.96<br>Se2-<br>selenide | 35 Br<br>bromine<br>79.90<br>Br⁻<br>bromide | 36 Kr<br>krypton<br>83.80<br>Kr<br>krypton |
| 46 Pd<br>palladium<br>106.40<br>Pd2+<br>palladium(II)<br>Pd4+<br>palladium(IV) | 47 Ag<br>silver<br>107.87<br>Ag+<br>silver | 48 Cd<br>cadmium<br>112.41<br>Cd2+<br>cadmium | 49 In<br>indium<br>114.82<br>In3+<br>indium | 50 Sn<br>tin<br>118.69<br>Sn4+<br>tin(IV)<br>Sn2+<br>tin(II) | 51 Sb<br>antimony<br>121.75<br>Sb3+<br>antimony(III)<br>Sb5+<br>antimony(V) | 52 Te<br>tellurium<br>127.60<br>Te2-<br>telluride | 53 I<br>iodine<br>126.90<br>I⁻<br>iodide | 54 Xe<br>xenon<br>131.30<br>Xe<br>xenon |
| 78 Pt<br>platinum<br>195.09<br>Pt4+<br>platinum(IV)<br>Pt2+<br>platinum(II) | 79 Au<br>gold<br>196.97<br>Au3+<br>gold(III)<br>Au+<br>gold(I) | 80 Hg<br>mercury<br>200.59<br>Hg2+<br>mercury(II)<br>Hg+<br>mercury(I) | 81 Tl<br>thallium<br>204.37<br>Tl+<br>thallium<br>Tl3+<br>thallium(III) | 82 Pb<br>lead<br>207.19<br>Pb2+<br>lead(II)<br>Pb4+<br>lead(IV) | 83 Bi<br>bismuth<br>208.98<br>Bi3+<br>bismuth(III)<br>Bi5+<br>bismuth(V) | 84 Po<br>polonium<br>(208.98)<br>Po2+<br>polonium(II)<br>Po4+<br>polonium(IV) | 85 At<br>astatine<br>(209.98)<br>At⁻<br>astatide | 86 Rn<br>radon<br>(222)<br>Rn<br>radon |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 63 Eu<br>europium<br>151.96<br>Eu3+<br>europium(III)<br>Eu2+<br>europium(II) | 64 Gd<br>gadolinium<br>157.25<br>Gd3+<br>gadolinium | 65 Tb<br>terbium<br>158.93<br>Tb3+<br>terbium | 66 Dy<br>dysprosium<br>162.50<br>Dy3+<br>dysprosium | 67 Ho<br>holmium<br>164.93<br>Ho3+<br>holmium | 68 Er<br>erbium<br>167.26<br>Er3+<br>erbium | 69 Tm<br>thulium<br>168.93<br>Tm3+<br>thulium | 70 Yb<br>ytterbium<br>173.04<br>Yb3+<br>ytterbium(III)<br>Yb2+<br>ytterbium(II) | 71 Lu<br>lutetium<br>174.97<br>Lu2+<br>lutetium |
| 95 Am<br>americium<br>(243.06)<br>Am3+<br>americium(III)<br>Am4+<br>americium(IV) | 96 Cm<br>curium<br>(247.07)<br>Cm3+<br>curium | 97 Bk<br>berkelium<br>(247.07)<br>Bk3+<br>berkelium(III)<br>Bk4+<br>berkelium(IV) | 98 Cf<br>californium<br>(242.06)<br>Cf3+<br>californium | 99 Es<br>einsteinium<br>(252.08)<br>Es3+<br>einsteinium | 100 Fm<br>fermium<br>(257.10)<br>Fm3+<br>fermium | 101 Md<br>mendelevium<br>(258.10)<br>Md2+<br>mendelevium(II)<br>Md3+<br>mendelevium(III) | 102 No<br>nobelium<br>(259.10)<br>No2+<br>nobelium(II)<br>No3+<br>nobelium(III) | 103 Lr<br>lawrencium<br>(260.11)<br>Lr3+<br>lawrencium |

## Nuclear Chemistry

| MASSES OF SELECTED NUCLIDES AND SUBATOMIC PARTICLES | | | |
|---|---|---|---|
| **Nuclide or Particle** | **Mass $(10^{-3}$ kg/mol$)$** | **Nuclide or Particle** | **Mass $(10^{-3}$ kg/mol$)$** |
| electron, ${}^{0}_{-1}e$ | 0.000 549 | sulphur-31, ${}^{31}_{16}$S | 30.970 77 |
| positron, ${}^{0}_{+1}e$ | 0.000 549 | potassium-40, ${}^{40}_{19}$K | 39.953 57 |
| proton, ${}^{1}_{1}$H | 1.007 28 | rubidium-90, ${}^{90}_{37}$Rb | 89.894 27 |
| neutron, ${}^{1}_{0}n$ | 1.008 67 | krypton-92, ${}^{92}_{36}$Kr | 91.906 01 |
| deuterium, ${}^{2}_{1}$H | 2.013 55 | strontium-95, ${}^{95}_{38}$Sr | 94.898 47 |
| helium-3, ${}^{3}_{2}$He | 3.014 93 | ruthenium-107, ${}^{107}_{44}$Ru | 106.885 98 |
| tritium, ${}^{3}_{1}$H | 3.015 50 | barium-141, ${}^{141}_{56}$Ba | 140.883 40 |
| alpha particle (helium nucleus), ${}^{4}_{2}$He | 4.001 50 | cesium-144, ${}^{144}_{55}$Cs | 143.901 18 |
| beryllium-7, ${}^{7}_{4}$Be | 7.014 70 | lanthanum-146, ${}^{146}_{57}$La | 145.894 14 |
| beryllium-8, ${}^{8}_{4}$Be | 8.003 11 | lead-206, ${}^{206}_{82}$Pb | 205.929 5 |
| boron-8, ${}^{8}_{5}$B | 8.021 86 | lead-208, ${}^{208}_{82}$Pb | 207.931 6 |
| nitrogen-13, ${}^{13}_{7}$N | 13.001 90 | polonium-210, ${}^{210}_{84}$Po | 209.936 8 |
| nitrogen-14, ${}^{14}_{7}$N | 13.999 231 | polonium-218, ${}^{218}_{84}$Po | 217.962 8 |
| carbon-14, ${}^{14}_{6}$C | 13.999 95 | radon-222, ${}^{222}_{86}$Rn | 221.970 3 |
| oxygen-15, ${}^{15}_{8}$O | 14.998 67 | radium-226, ${}^{226}_{88}$Ra | 225.977 1 |
| fluorine-17, ${}^{17}_{9}$F | 16.997 15 | thorium-230, ${}^{230}_{90}$Th | 229.983 7 |
| neon-20, ${}^{20}_{10}$Ne | 19.986 95 | uranium-235, ${}^{235}_{92}$U | 234.993 4 |
| phosphorus-31, ${}^{31}_{15}$P | 30.965 53 | plutonium-239, ${}^{239}_{94}$Pu | 239.000 6 |

| ELEMENTS FOR RADIOACTIVE DATING | | |
|---|---|---|
| **Radioisotope** | **Approximate Half-life (a)** | **Decay Product** |
| ${}^{14}_{6}$C (carbon-14) | $5.73\times10^{3}$ | ${}^{14}_{7}$N (nitrogen-14) |
| ${}^{40}_{19}$K (potassium-40) | $1.28\times10^{9}$ | ${}^{40}_{18}$Ar (argon-40) |
| ${}^{87}_{37}$Rb (rubidium-87) | $4.86\times10^{10}$ | ${}^{87}_{38}$Sr (strontium-87) |
| ${}^{235}_{92}$U (uranium-235) | $7.13\times10^{8}$ | ${}^{207}_{82}$Pb (lead-207) |
| ${}^{238}_{92}$U (uranium-238) | $4.51\times10^{9}$ | ${}^{206}_{82}$Pb (lead-206) |

## Organic Chemistry

| HOMOLOGOUS SERIES OF ALKANES (state at room temperature and pressure) | |
|---|---|
| **Name** | **Chemical Formula** |
| methane | $CH_{4(g)}$ |
| ethane | $C_2H_{6(g)}$ |
| propane | $C_3H_{8(g)}$ |
| butane | $C_4H_{10(g)}$ |
| pentane | $C_5H_{12(l)}$ |
| hexane | $C_6H_{14(l)}$ |
| heptane | $C_7H_{16(l)}$ |
| octane | $C_8H_{18(l)}$ |
| nonane | $C_9H_{20(l)}$ |
| decane | $C_{10}H_{22(l)}$ |

| PREFIXES FOR MOLECULAR COMPOUNDS | |
|---|---|
| 1 = mono- | 6 = hexa- |
| 2 = di- | 7 = hepta- |
| 3 = tri- | 8 = octa- |
| 4 = tetra- | 9 = ennea- (nona-) |
| 5 = penta- | 10 = deca- |

| FUNCTIONAL GROUPS | |
|---|---|
| $R-O-H$ | alcohol |
| $R-C(=O)-H$ | aldehyde |
| $R-C(=O)-O-H$ | carboxylic acid |
| $R-C(=O)-R'$ | ketone |
| $R-C(=O)-O-R'$ | ester |
| $R-Q$ | halide |
| $-(x-y)_n-$ | polymers |

R is usually a carbon group
Q stands for a halogen
x-y is a monomer unit

## Solutions

| SOLUBILITY OF SOME COMMON IONIC COMPOUNDS IN WATER AT 298.15 K (25°C) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Ion** | **Group 1**<br>$NH_4^+$<br>$H^+ (H_3O^+)$ | $ClO_3^-$<br>$NO_3^-$<br>$ClO_4^-$ | $CH_3COO^-$ | $Cl^-$<br>$Br^-$<br>$I^-$ | $SO_4^{2-}$ | $S^{2-}$ | $OH^-$ | $PO_4^{3-}$<br>$SO_3^{2-}$<br>$CO_3^{2-}$ |
| Solubility greater than or equal to 0.1 mol/L (very soluble) | all | all | most | most | most | Group 1<br>Group 2<br>$NH_4^+$ | Group 1<br>$NH_4^+$<br>$Sr^{2+}$<br>$Ba^{2+}$<br>$Tl^+$ | Group 1<br>$NH_4^+$ |
| Solubility less than or equal to 0.1 mol/L (slightly soluble) | none | none | $Ag^+$ | $Ag^+$<br>$Pb^{2+}$<br>$Hg^+$<br>$Cu^+$<br>$Tl^+$ | $Ca^{2+}$<br>$Sr^{2+}$<br>$Ba^{2+}$<br>$Ra^{2+}$<br>$Pb^{2+}$<br>$Ag^+$ | most | most | most |

## Stoichiometry and Solution Formulas

$n = \frac{m}{M}$

$C = \frac{n}{V}$

$C_1 V_1 = C_2 V_2$

$n_r = n_g \times \frac{\text{coefficient}_r}{\text{coefficient}_g}$

$C$ = concentration (mol/L)
$m$ = mass (g)
$M$ = molar mass (g/mol)
$n$ = number of moles (mol)
$V$ = volume (L)
r = required substance
g = given substance

| METHODS OF EXPRESSING CONCENTRATION | | | |
|---|---|---|---|
| **Moles per Litre (mol/L)** | **Parts per Million (ppm)** | **Percent Mass/Volume (% *m*/*V*)** | **Percent by Volume (% *V*/*V*)** |
| $\frac{\text{mol solute}}{\text{L solution}}$ | $\frac{\text{g solute}}{\text{g solution}} \times 10^6$ | $\frac{\text{g solute}}{\text{mL solution}} \times 100$ | $\frac{\text{mL solute}}{\text{mL solution}} \times 100$ |

| COLOUR CHART OF COMMON AQUEOUS IONS | | | | | |
|---|---|---|---|---|---|
| **Ion** | **Symbol** | **Colour** | **Ion** | **Symbol** | **Colour** |
| chromate | $CrO_4^{2-}$ | yellow | dichromate | $Cr_2O_7^{2-}$ | orange |
| chromium(III) | $Cr^{3+}$ | green | iron(II) | $Fe^{2+}$ | pale green |
| chromium(II) | $Cr^{2+}$ | blue | iron(III) | $Fe^{3+}$ | pale yellow |
| cobalt(II) | $Co^{2+}$ | pink | manganese(II) | $Mn^{2+}$ | pale pink |
| copper(I) | $Cu^{+}$ | green | permanganate | $MnO_4^{-}$ | purple |
| copper(II) | $Cu^{2+}$ | blue | | | |

# Acids and Bases

## Acid Formulas

$pH = -\log_{10}\left[H_3O^+_{(aq)}\right] \quad \left[H_3O^+_{(aq)}\right] = \text{antilog}_{10}\left[-pH\right]$

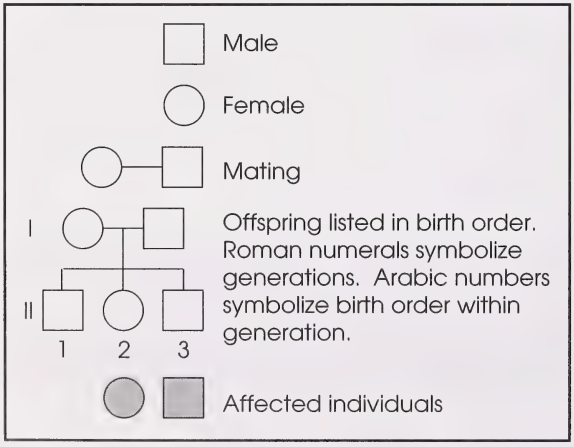
| IUPAC RULES FOR NAMING ACIDS | | | | |
|---|---|---|---|---|
| | | **Example** | | |
| **Ionic Name** | **Acid Name** | **Formula** | **Ionic Name** | **Acid Name** |
| hydrogen –ide | hydro –ic acid | $HCl_{(aq)}$ | hydrogen chloride | hydrochloric acid |
| hydrogen –ate | –ic acid | $H_3PO_{4(aq)}$ | hydrogen phosphate | phosphoric acid |
| hydrogen –ite | –ous acid | $H_3PO_{3(aq)}$ | hydrogen phosphite | phosphorous acid |

| RELATIVE STRENGTHS OF ACIDS AND BASES AT 0.10 mol/L AND 298.15 K (25°C) | | |
|---|---|---|
| **Acid Name** | **Acid Formula** | **Conjugate Base Formula** |
| hydrochloric acid | $HCl_{(aq)}$ | $Cl^{-}{}_{(aq)}$ |
| sulphuric acid | $H_2SO_{4(aq)}$ | $HSO_4{}^{-}{}_{(aq)}$ |
| nitric acid | $HNO_{3(aq)}$ | $NO_3{}^{-}{}_{(aq)}$ |
| hydronium ion | $H_3O^{+}{}_{(aq)}$ | $H_2O_{(l)}$ |
| oxalic acid | $HOOCCOOH_{(aq)}$ | $HOOCCOO^{-}{}_{(aq)}$ |
| sulphurous acid $(SO_2 + H_2O)$ | $H_2SO_{3(aq)}$ | $HSO_3{}^{-}{}_{(aq)}$ |
| hydrogen sulphate ion | $HSO_4{}^{-}{}_{(aq)}$ | $SO_4{}^{2-}{}_{(aq)}$ |
| phosphoric acid | $H_3PO_{4(aq)}$ | $H_2PO_4{}^{-}{}_{(aq)}$ |
| orange IV | $HOr_{(aq)}$ | $Or^{-}{}_{(aq)}$ |
| nitrous acid | $HNO_{2(aq)}$ | $NO_2{}^{-}{}_{(aq)}$ |
| hydrofluoric acid | $HF_{(aq)}$ | $F^{-}{}_{(aq)}$ |
| methanoic acid | $HCOOH_{(aq)}$ | $HCOO^{-}{}_{(aq)}$ |
| methyl orange | $HMo_{(aq)}$ | $Mo^{-}{}_{(aq)}$ |
| benzoic acid | $C_6H_5COOH_{(aq)}$ | $C_6H_5COO^{-}{}_{(aq)}$ |
| ethanoic (acetic) acid | $CH_3COOH_{(aq)}$ | $CH_3COO^{-}{}_{(aq)}$ |
| carbonic acid $(CO_2 + H_2O)$ | $H_2CO_{3(aq)}$ | $HCO_3{}^{-}{}_{(aq)}$ |
| bromothymol blue | $HBb_{(aq)}$ | $Bb^{-}{}_{(aq)}$ |
| hydrosulphuric acid | $H_2S_{(aq)}$ | $HS^{-}{}_{(aq)}$ |
| phenolphthalein | $HPh_{(aq)}$ | $Ph^{-}{}_{(aq)}$ |
| boric acid | $H_3BO_{3(aq)}$ | $H_2BO_3{}^{-}{}_{(aq)}$ |
| ammonium ion | $NH_4{}^{+}{}_{(aq)}$ | $NH_{3(aq)}$ |
| hydrogen carbonate ion | $HCO_3{}^{-}{}_{(aq)}$ | $CO_3{}^{2-}{}_{(aq)}$ |
| indigo carmine | $HIc_{(aq)}$ | $Ic^{-}{}_{(aq)}$ |
| water (55.5 mol/L) | $H_2O_{(l)}$ | $OH^{-}{}_{(aq)}$ |

| ACID-BASE INDICATORS AT 298.15 K (25°C) | | | |
|---|---|---|---|
| **Indicator** | **Abbreviation** | **pH Range** | **Colour Change As pH Increases** |
| methyl violet | HMv | 0.0 – 1.6 | yellow to blue |
| thymol blue | $H_2Tb$ | 1.2 – 2.8 | red to yellow |
| thymol blue | $HTb^-$ | 8.0 – 9.6 | yellow to blue |
| orange IV | HOr | 1.4 – 2.8 | red to yellow |
| methyl orange | HMo | 3.2 – 4.4 | red to yellow |
| bromocresol green | HBg | 3.8 – 5.4 | yellow to blue |
| litmus | HLt | 4.5 – 8.3 | red to blue |
| methyl red | HMr | 4.8 – 6.0 | red to yellow |
| chlorophenol red | HCh | 5.2 – 6.8 | yellow to red |
| bromothymol blue | HBb | 6.0 – 7.6 | yellow to blue |
| phenol red | HPr | 6.6 – 8.0 | yellow to red |
| phenolphthalein | HPh | 8.2 – 10.0 | colourless to pink |
| thymolphthalein | HTh | 9.4 – 10.6 | colourless to blue |
| alizarin yellow R | HAy | 10.1 – 12.0 | yellow to red |
| indigo carmine | HIc | 11.4 – 13.0 | blue to yellow |
| 1,3,5-trinitrobenzene | HNb | 12.0 – 14.0 | colourless to orange |

## Genetics

### Pedigree Chart




| ABBREVIATIONS FOR NITROGEN BASES | |
|---|---|
| **Nitrogen Base** | **Abbreviation** |
| Adenine | A |
| Cytosine | C |
| Guanine | G |
| Thymine | T |
| Uracil | U |

## Scoring Guides

| SCORING GUIDE FOR KNOWLEDGE | |
|---|---|
| **Score** | **Scoring Descriptions** |
| 4<br><br>**Standard of Excellence** | The response is **well organized** and addresses **all** the major points of the question. **Relevant** scientific, technological, and/or societal concepts and examples are identified and interraltionships are **explicit**. The descriptions and/or explanations of these concepts are **correct**, **well organized**, and **reflect thorough understanding** and **logical consistency of thought**. The student uses complete sentences that make **effective** use of scientific vocabulary. When appropriate, suitable **metaphors**, **similes**, diagrams, and/or sketches are used to illustrate descriptions and/or explanations. |
| 3 | The response is **organized** and addresses **most** of the major points of the question. **Relevant** scientific, technological, and/or societal concepts and examples are **identified** and interrelationships are **evident**. The descriptions and/or explanations of these concepts are **organized** and **reflect correct understanding**. The student uses complete sentences that employ **correct** scientific vocabulary. When appropriate, suitable diagrams or sketches are used. |
| 2<br><br>**Acceptable Standard** | The response addresses **some** of the major points of the question. **Relevant** scientific, technological, and/or societal concepts and examples are **identified**, but **few** interrelationships are shown. The descriptions and/or explanations of these concepts are **superficial** and **somewhat disorganized**. The student uses complete sentences but the **use of appropriate scientific vocabulary is inconsistent**. |
| 1 | The response addresses **few** major points of the question. Concepts are **identified** but **interrelationships are not evident**. The student **superficially** describes the concepts in sentences but **organizational skills and scientific vocabulary are minimal**. |
| 0 | The response does not address any of the major points of the question at an **appropriate level** for a 30-level course. |

| SCORING GUIDE FOR SKILLS | |
|---|---|
| **Score** | **Scoring Descriptions** |
| 4<br><br>**Standard of Excellence** | The problem is **thoroughly understood**. An **appropriate** and **practical** design is presented. The data are **accurately** and **completely** analysed. **Accurate** interpretations and conclusions are made, **based on an analysis of the data**. The evaluation of the overall study is based on a **thorough understanding** of the principles of scientific inquiry. |
| 3 | The problem is **well understood**. An **appropriate** and **somewhat practical** design is presented. The data are **completely** analysed. Interpretations and conclusions are made **based on an analysis of the data**. The evaluation of the overall study is based on a **correct understanding** of the principles of scientific inquiry. |
| 2<br><br>**Acceptable Standard** | The problem is **understood**. The design is **generally appropriate**, or a **practical** procedure with **some omissions or errors** is presented. The data are **partially** analysed. Interpretations and conclusions are made **generally based on an analysis of the data**. The evaluation of the overall study is based on a **generally correct understanding** of the principles of scientific inquiry. |
| 1 | The proble is **poorly understood**. The design is **incomplete**, or an **impractical** procedure with **major omissions or errors** is presented. The data are **incorrectly** analysed. Interpretations and conclusions are **incorrect** or are **not based on an analysis of the data**. The evaluation study is based on a **superficial understanding** of the principles of scientific inquiry. |
| 0 | The response does not address any of the major points of the question at an **appropriate level** for a 30-level course. |

| SCORING GUIDE FOR STS | |
|---|---|
| **Score** | **Scoring Descriptions** |
| 4<br><br>**Standard of Excellence** | The design and function of the technological device are **clearly explained**. The interrelationships among science, technology, and society are **thoroughly understood**. Risks and benefits are **thoroughly evaluated**. **Insightful** and **convincing** arguments are used to support a decision or judgement and **a range of viewpoints** is considered. |
| 3 | The design and function of the technological device are **explained**. The interrelationships among science, technology, and society are **understood**. Risks and benefits are **evaluated**. **Clear** and **logical** arguments are used to support a decision or judgement and **alternative points-of-view** are considered. |
| 2<br><br>**Acceptable Standard** | The design and function of the technological devise are **described**. The interrelationships among science, technology, and society are **generally understood**. Risks and benefits are **listed**. **Logical** arguments are used to support a decision or judgement and **polar points of view** are considered. |
| 1 | The design and function of the technological device are **incorrectly descirbed**. The interrelationships among science, technology, and society are **poorly understood**. **Few** risks and benefits are **listed**. **Poorly formed** arguments are used to support a decision or judgement and **only one point of view** is considered. |
| 0 | The response does not address any of the major points of the question at an **appropriate level** for a 30-level course. |

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